High Voltage R&D in Liquid Argon

Sarah Lockwitz, *FNAL*
February 14, 2014

Recent Interest in LAr High Voltage (HV)

Experiment	Status
ICARUS	2001, Running 2010
Darkside 50	Running
MicroBooNE	Run this year
CAPTAIN	Built this year
LBNE	?
GLACIER	R&D Phase

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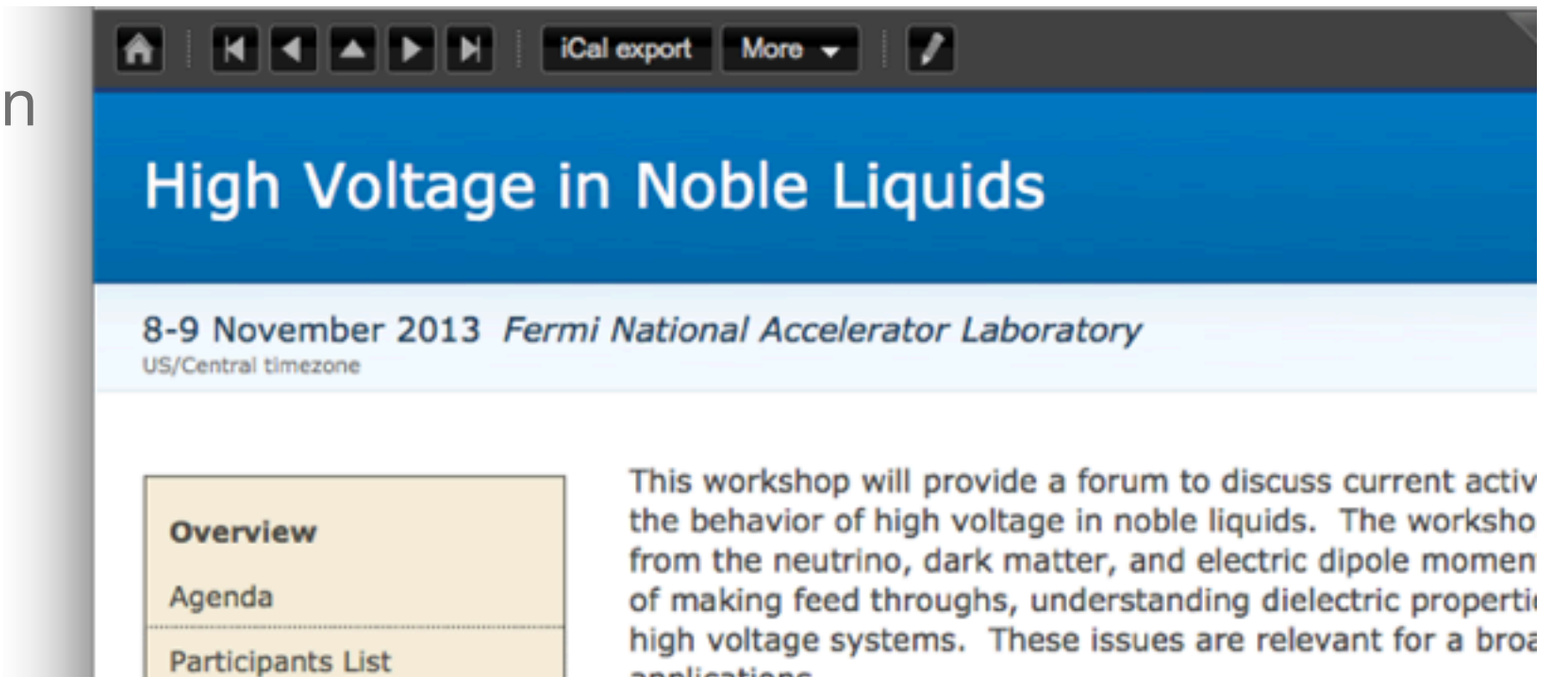
- In November 2013, FNAL hosted the "High Voltage in Nobel Liquids" workshop with ~40 attendees



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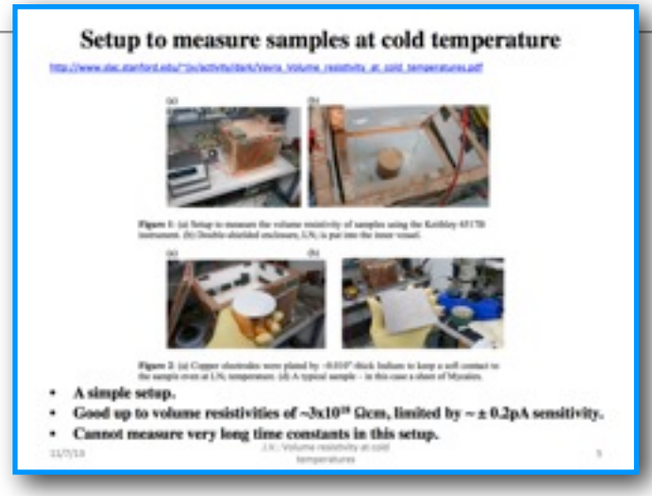

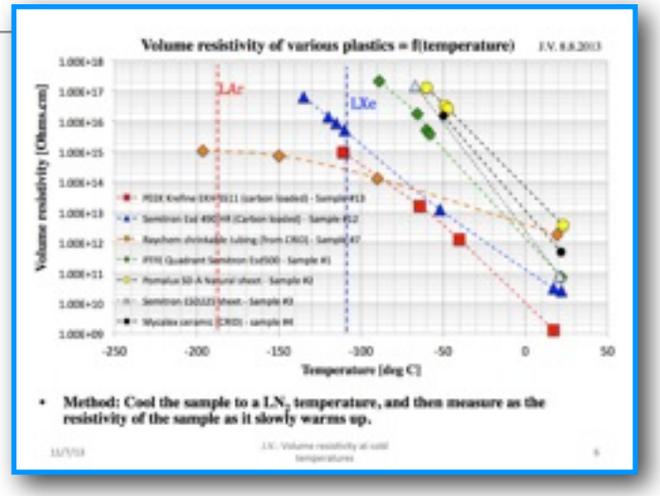

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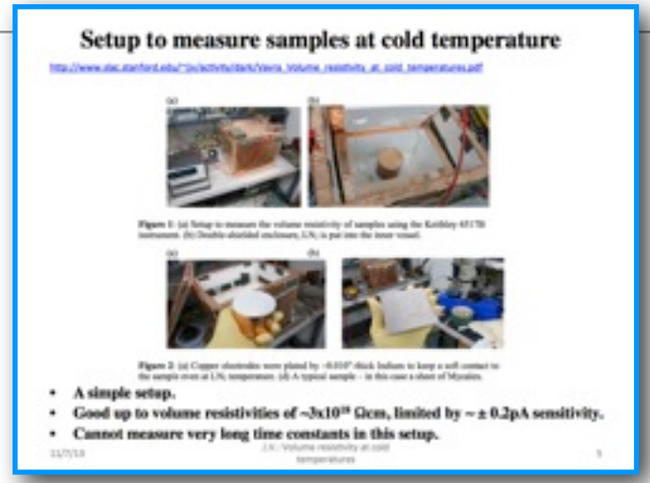

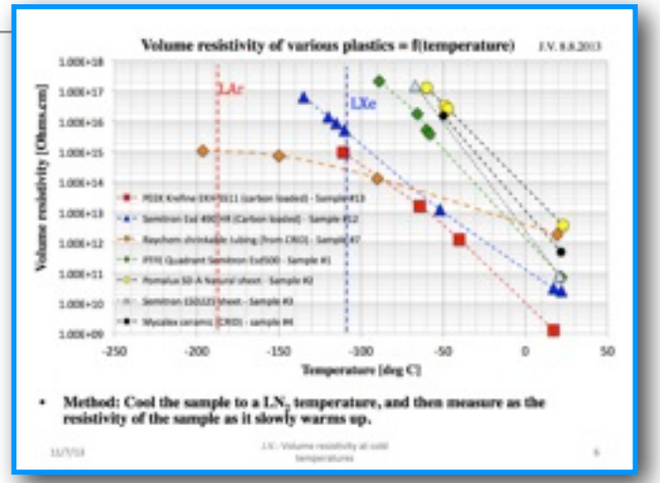

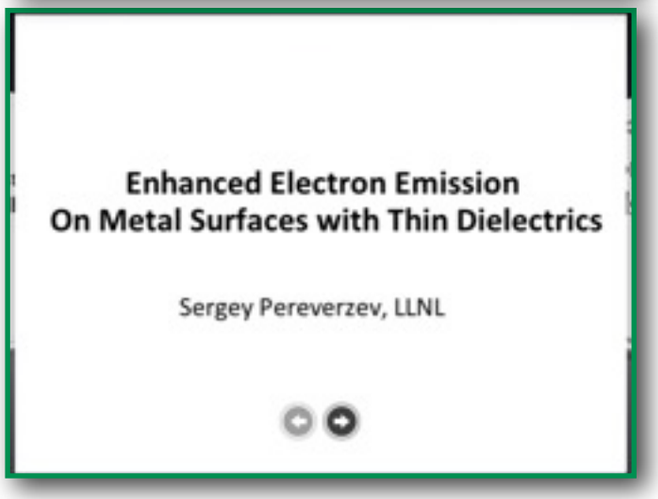

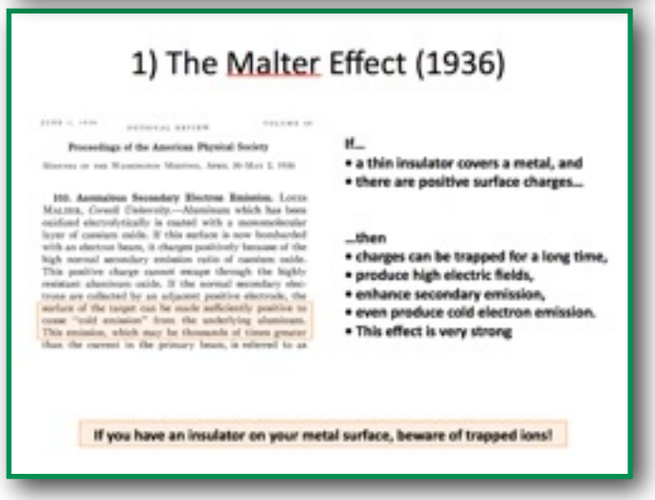

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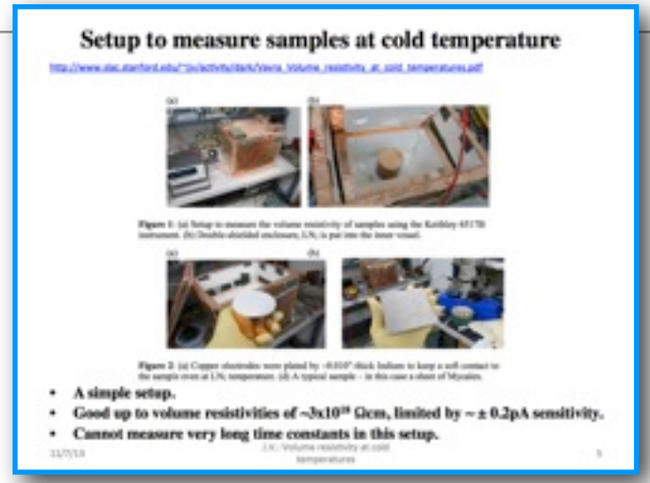
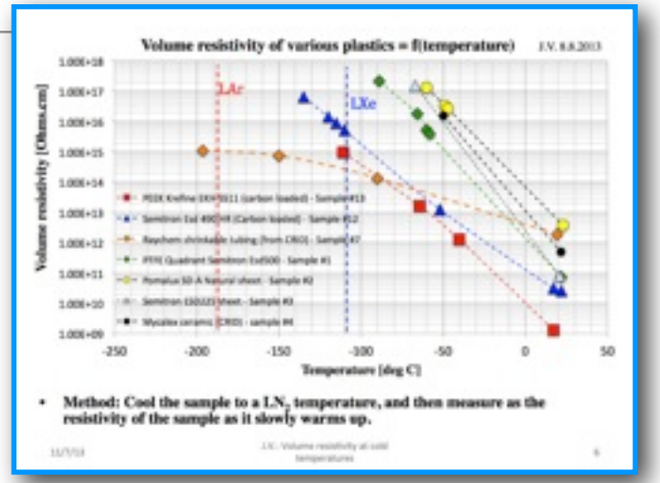
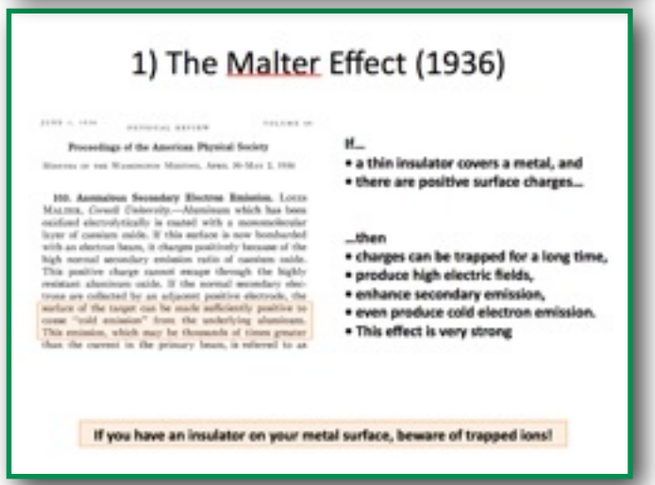
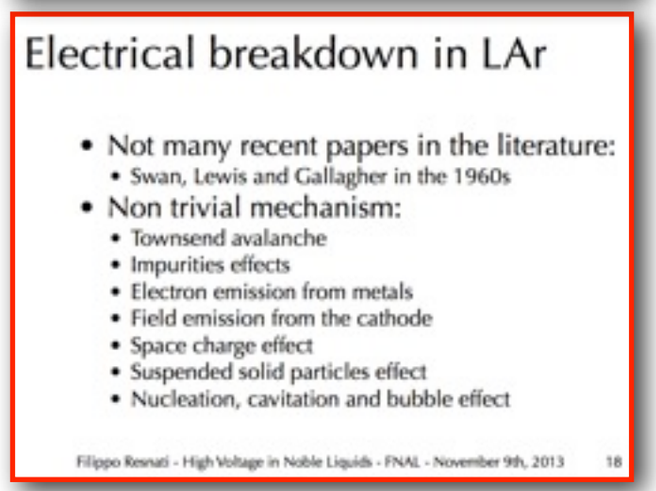
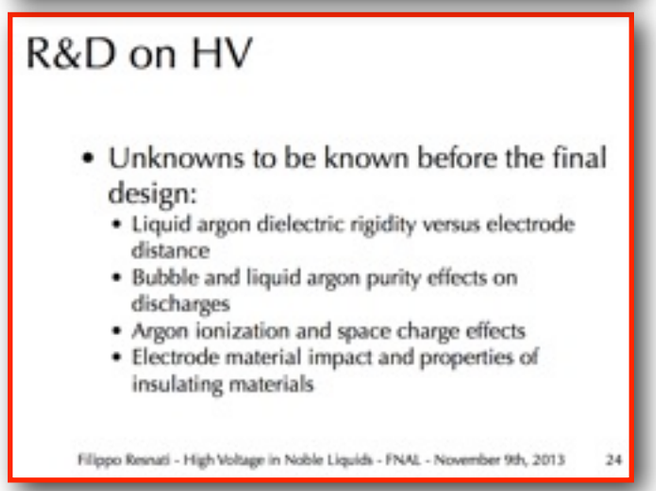
  - Pereverzev (LLNL): Discussed monolayer ideas and tests
  - Resnati (ETH Zurich): R&D for Glacier (HV @ MV scale); (1 cm LAr dieletric strength test here)
  - and more...











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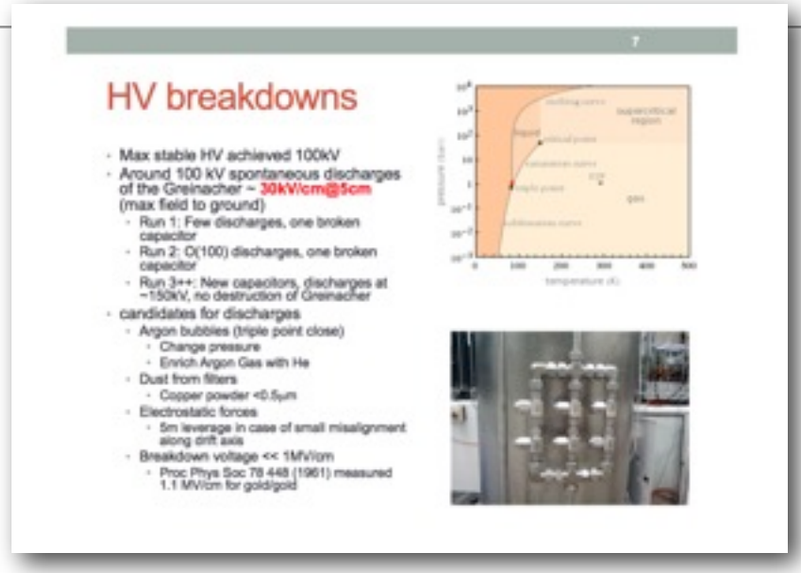

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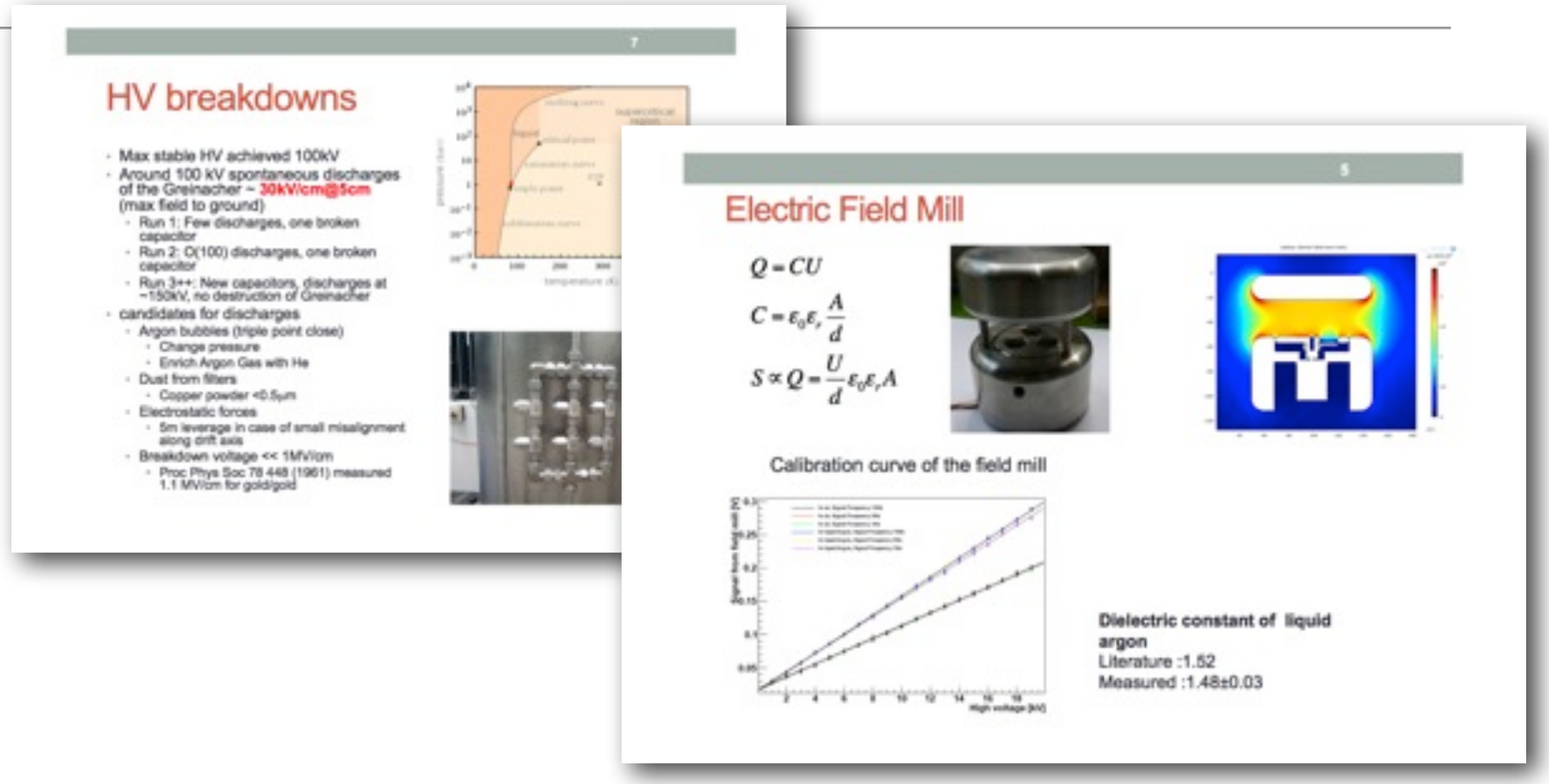

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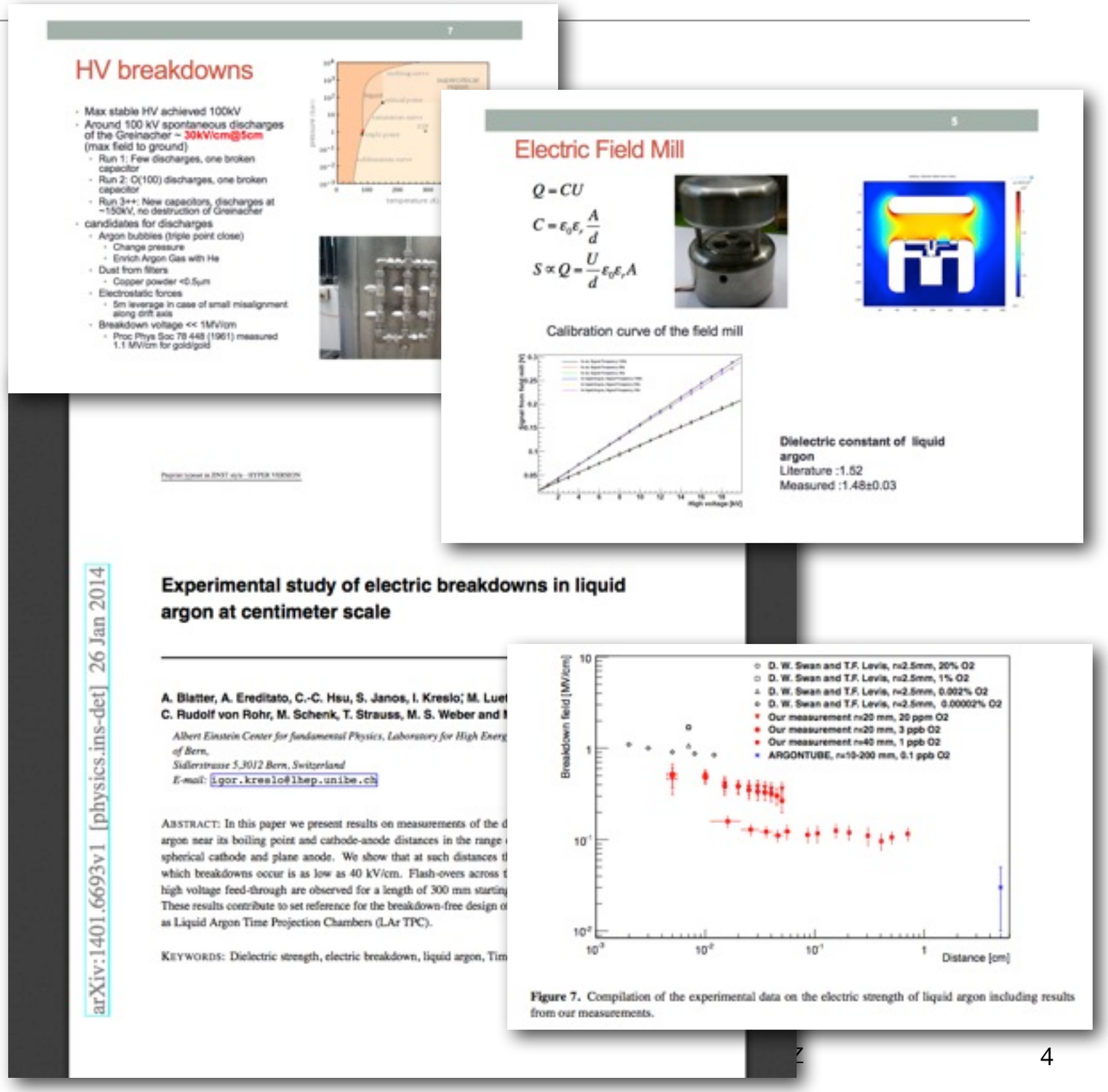
  - Measured the dielectric
  - Measuring electric strength of LAr vs. distance and purity (issue) (link)



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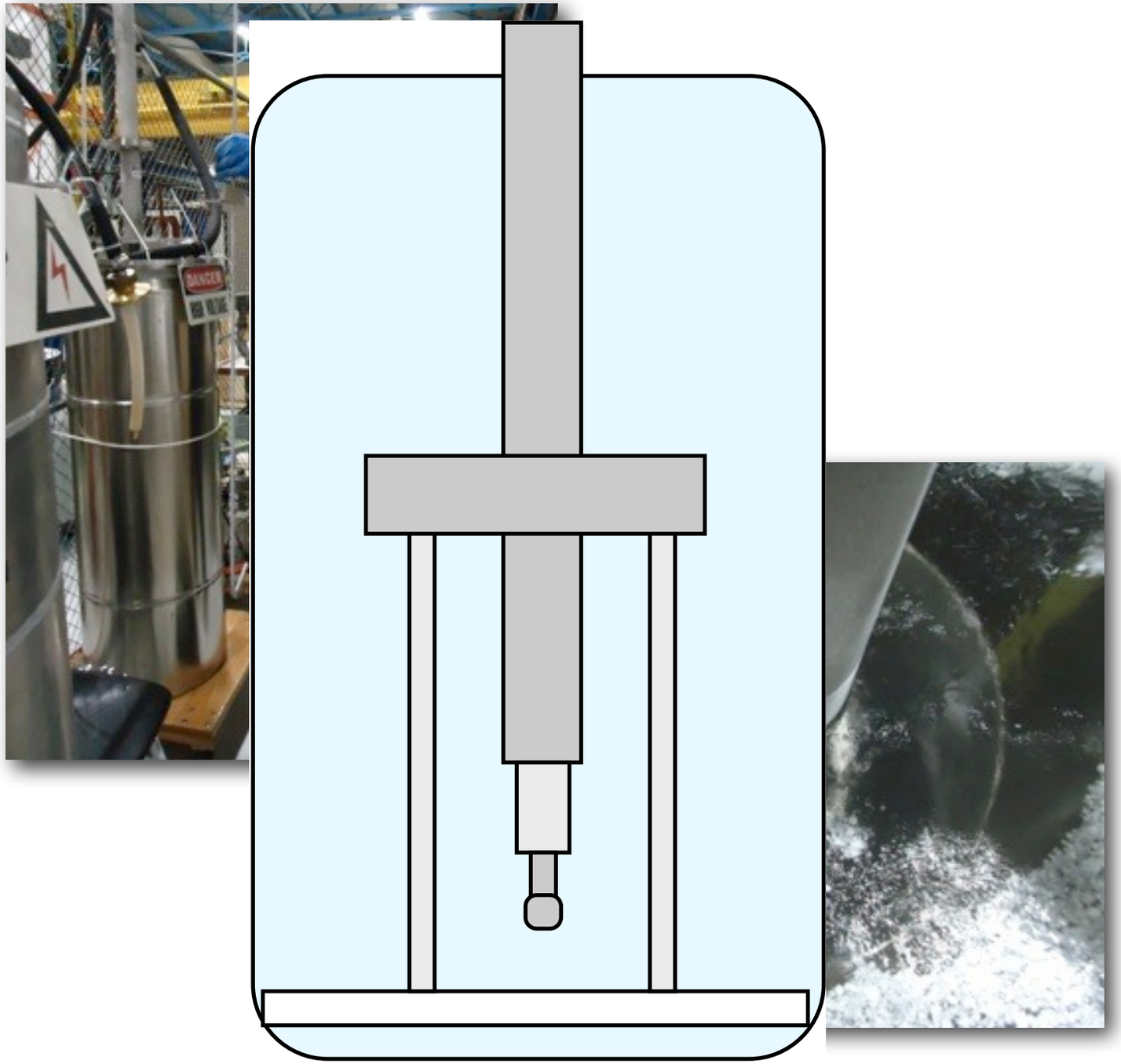

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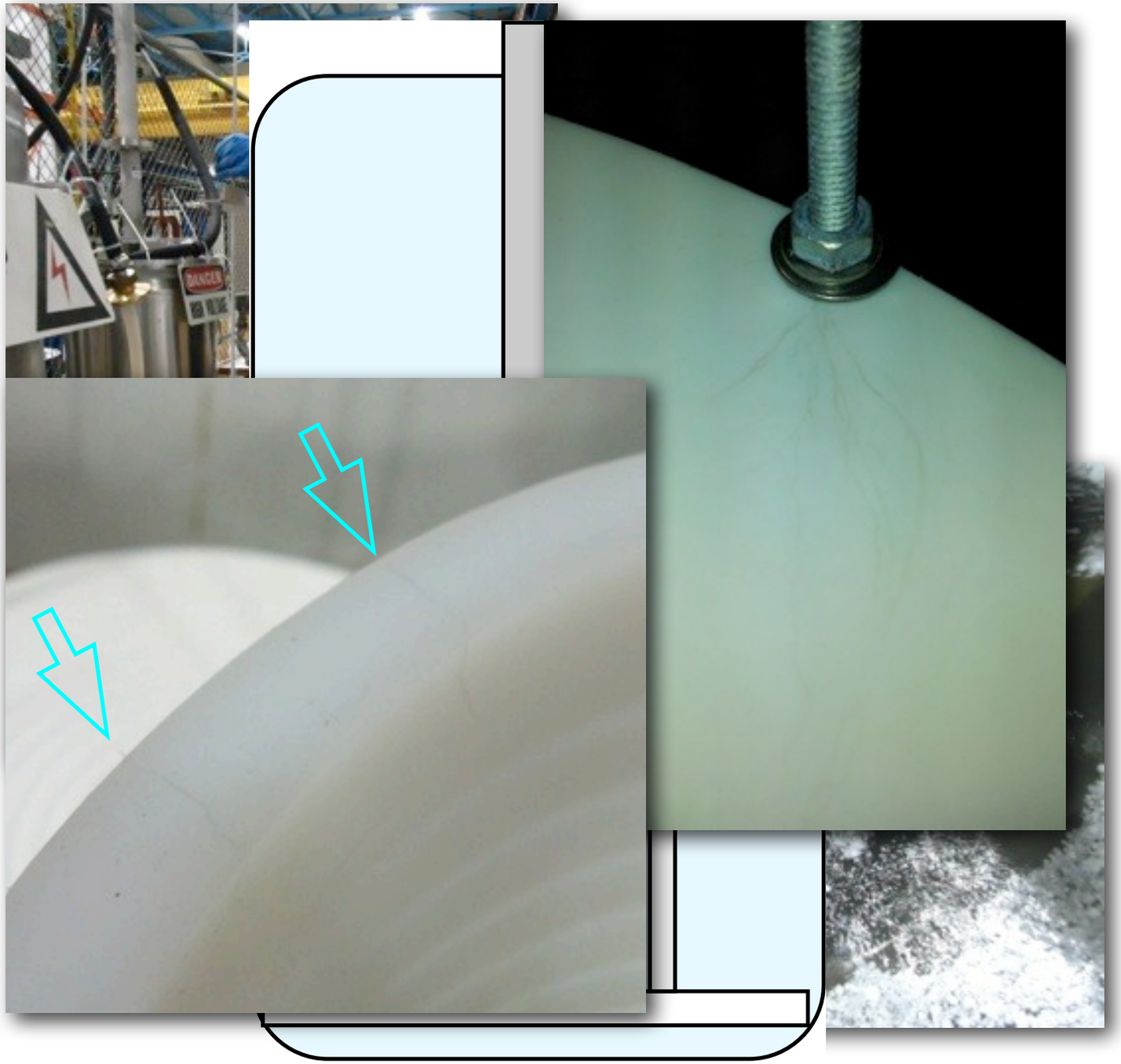

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TABLE 6.2

Electric strengths of liquefied gases

Liquid	Strength (MV cm^{-1})
Nitrogen	1·6–1·88
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    - Upon closer inspection, this value seems to come from a measurement at very small distances using very small spheres

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The apparatus and experimental techniques were the same as those described in the earlier paper (Swan and Lewis 1960). The electrodes were 5 mm diameter spheres and the electrode spacing could be adjusted externally by means of a micrometer. The procedure for obtaining reproducible surface oxide conditions

less than 1 μsec for electrode spacings of about 5×10^{-3} cm. In the present case for liquid argon at similar spacings T_0 is seen to be greater than 10 μsec for most of the electrode

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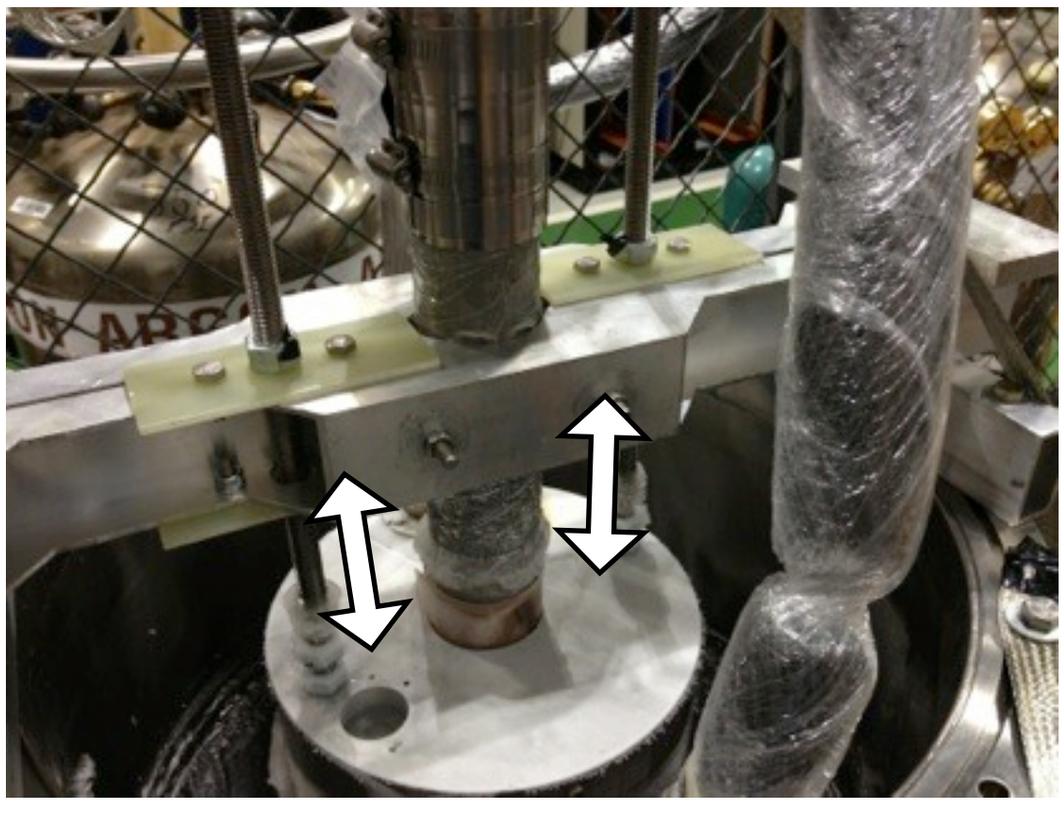
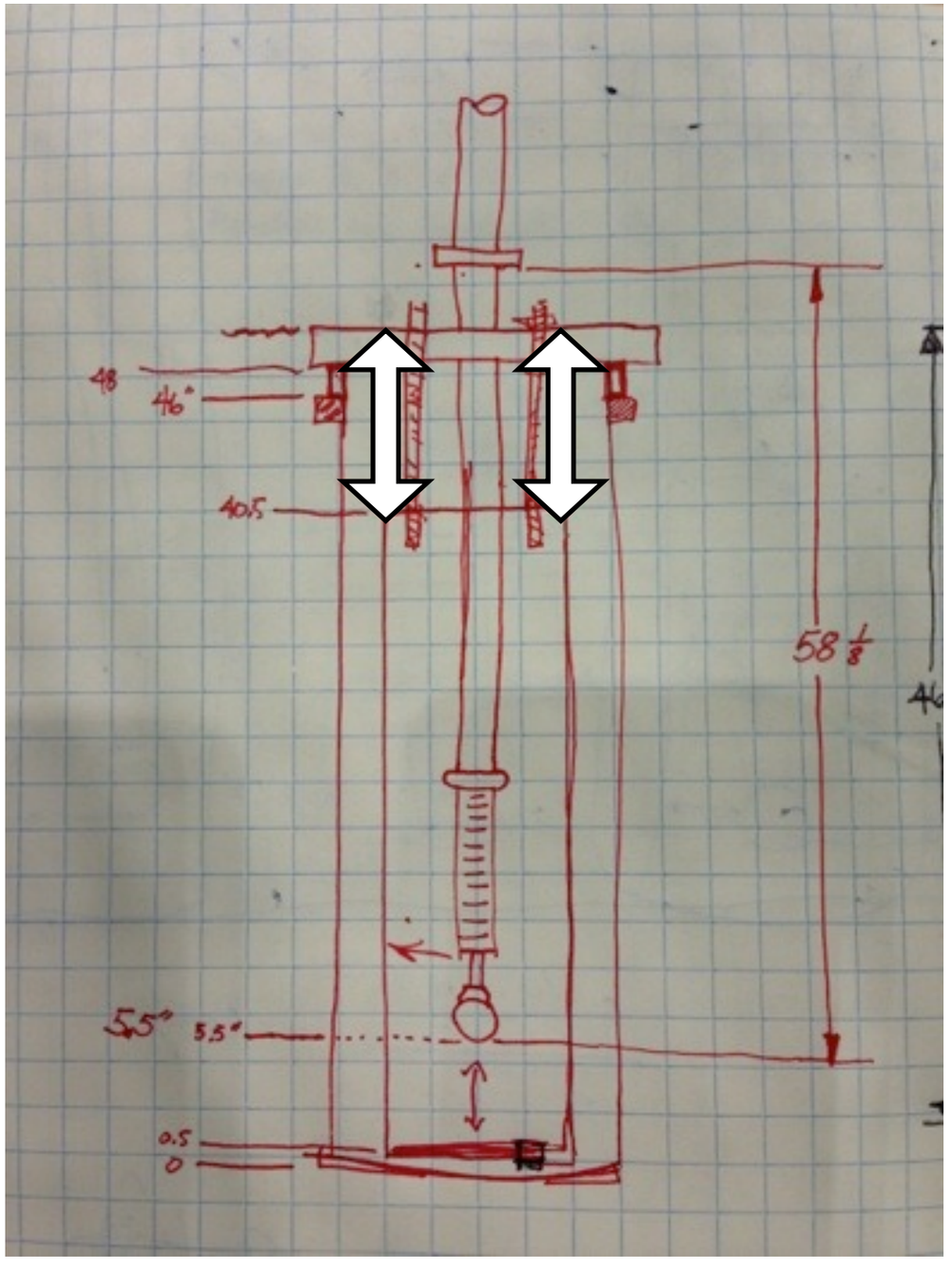
- This led us to try to measure the electric strength of LAr vs. distance at DAB this past summer
  - *caveat*: This is in an open dewar (impurities)





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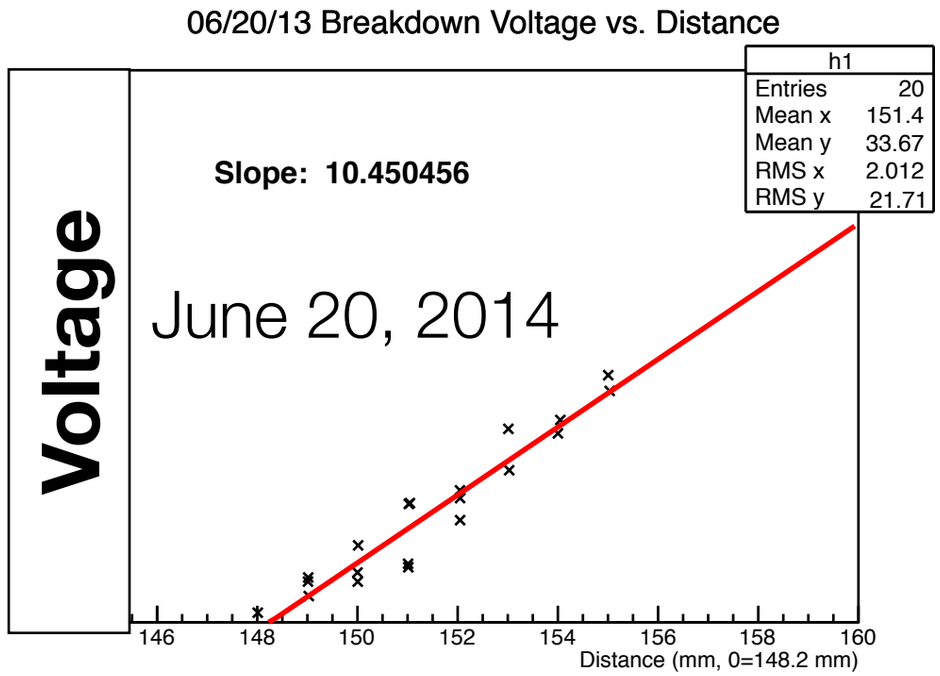

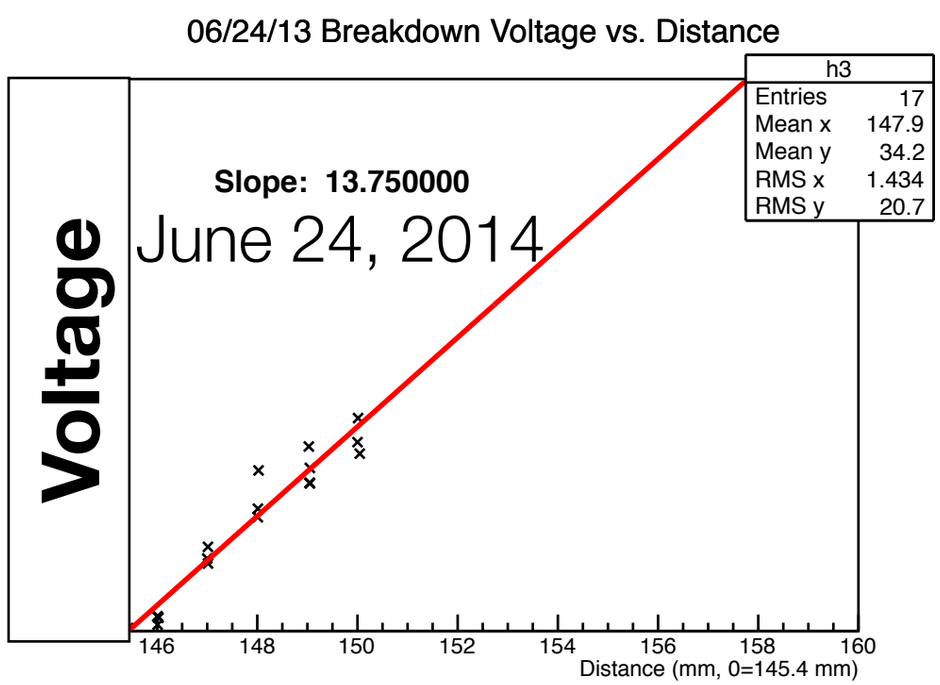

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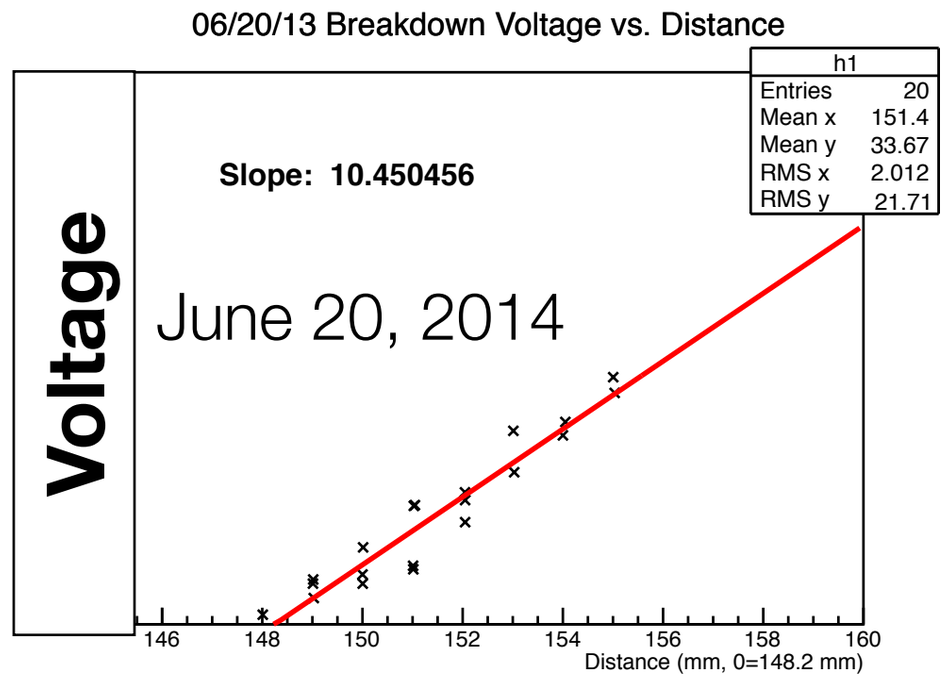

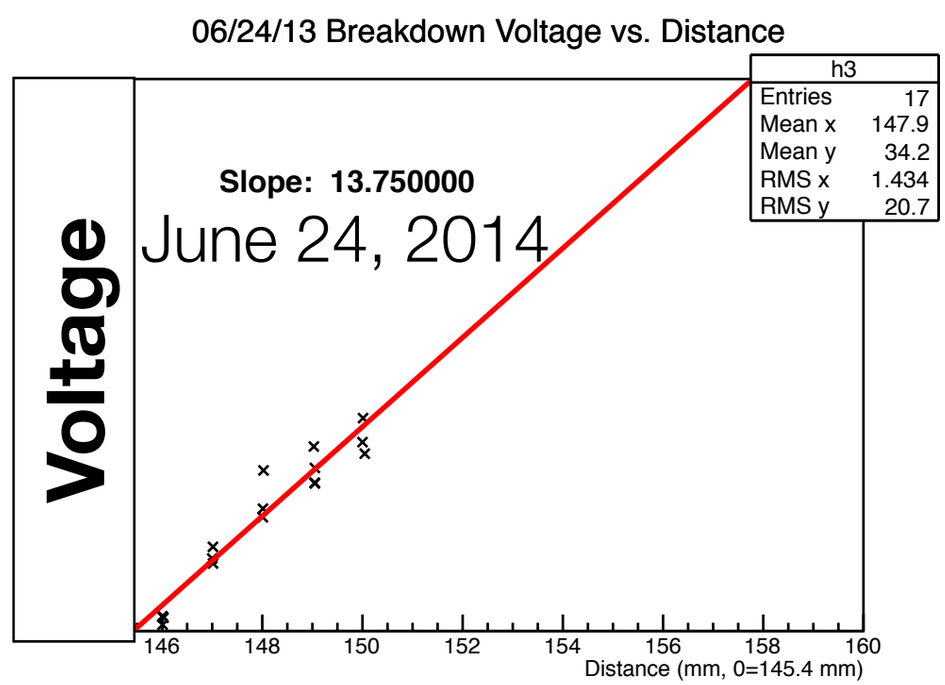

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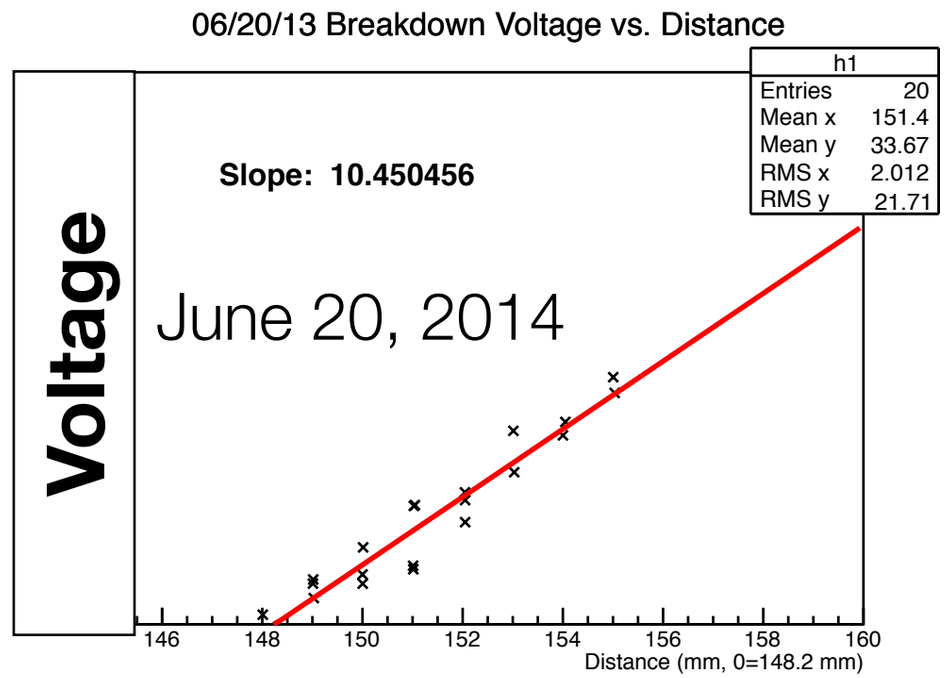

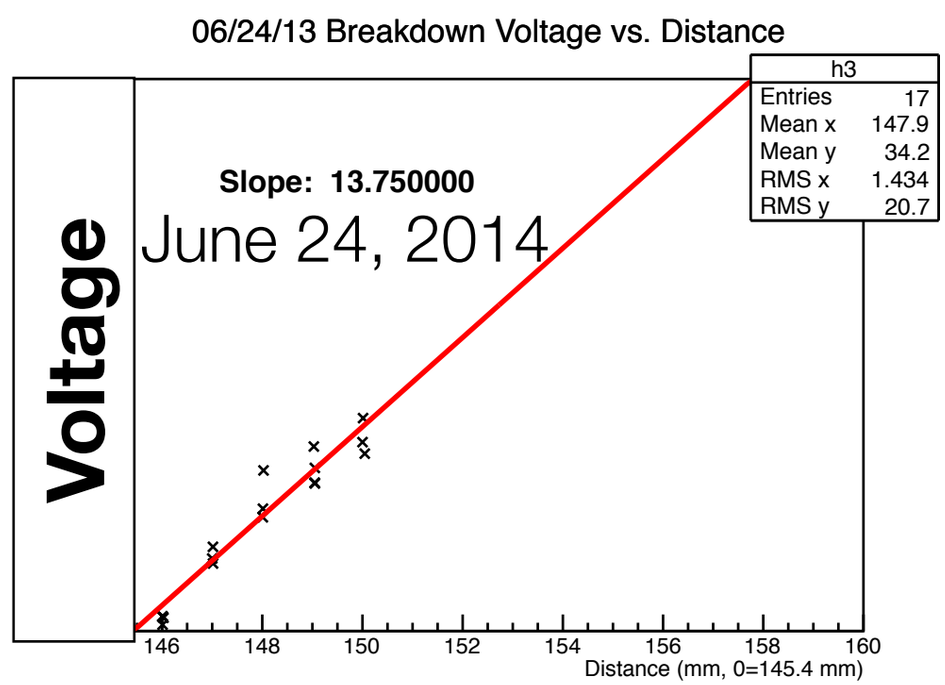

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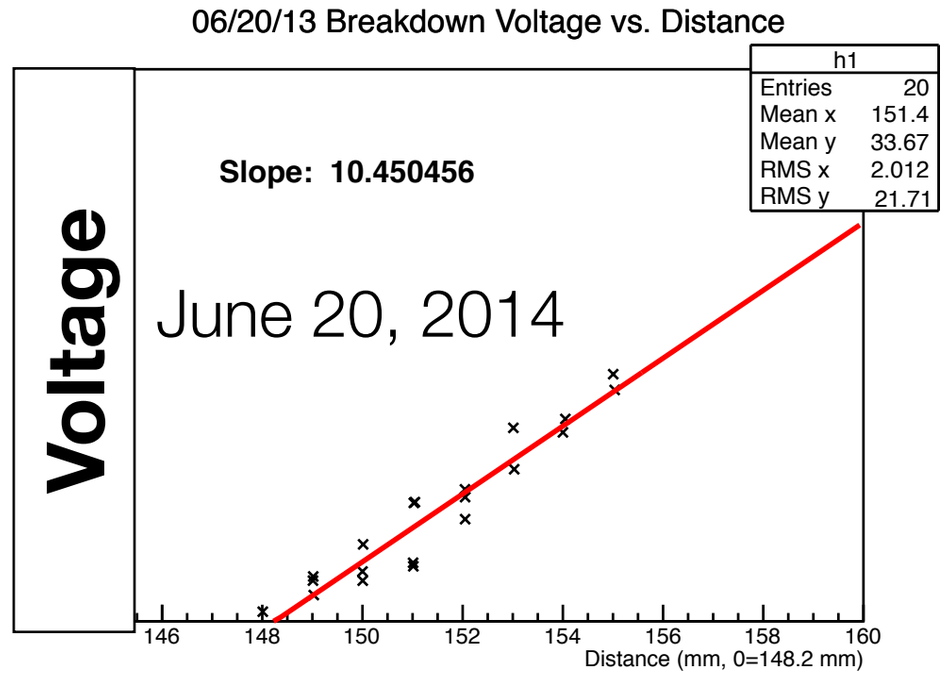

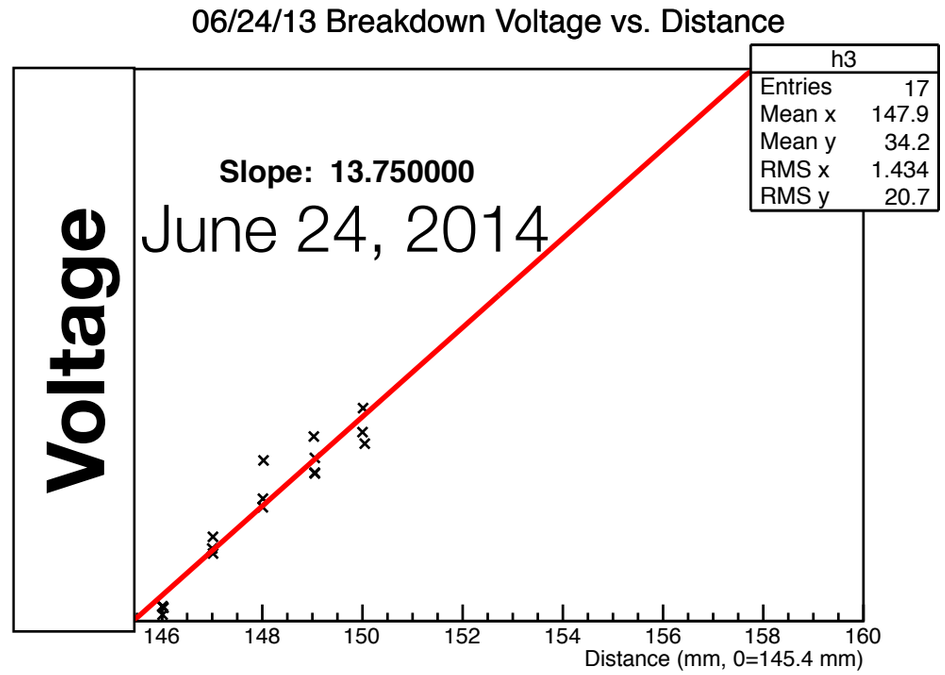

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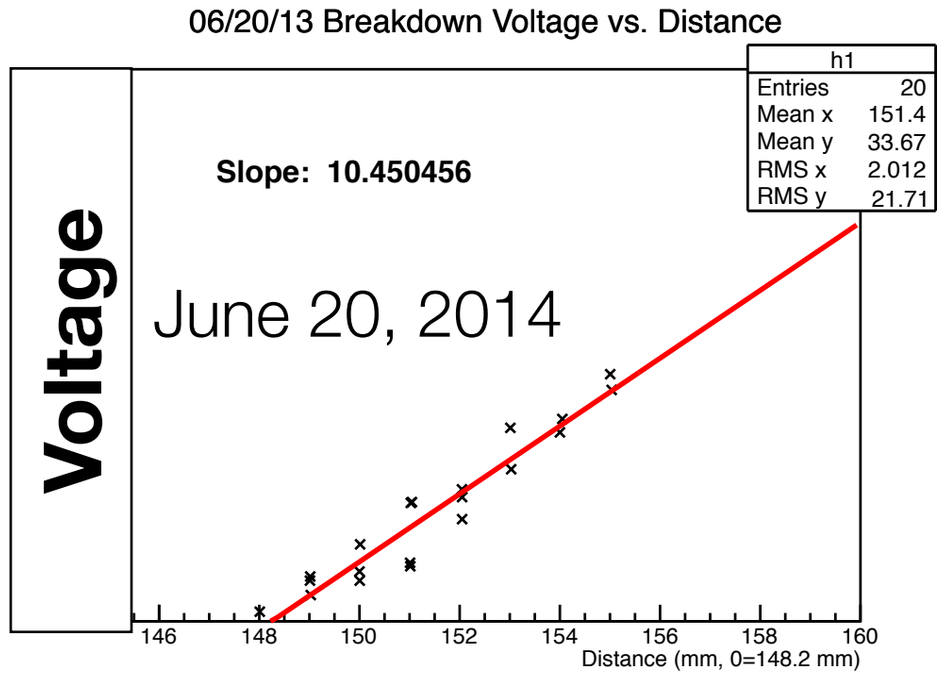
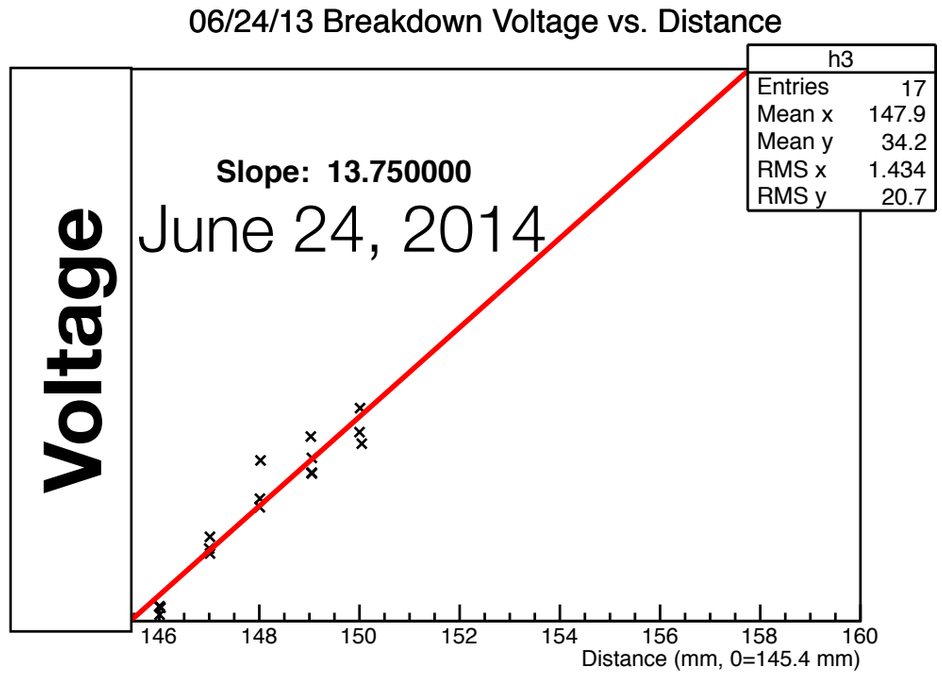
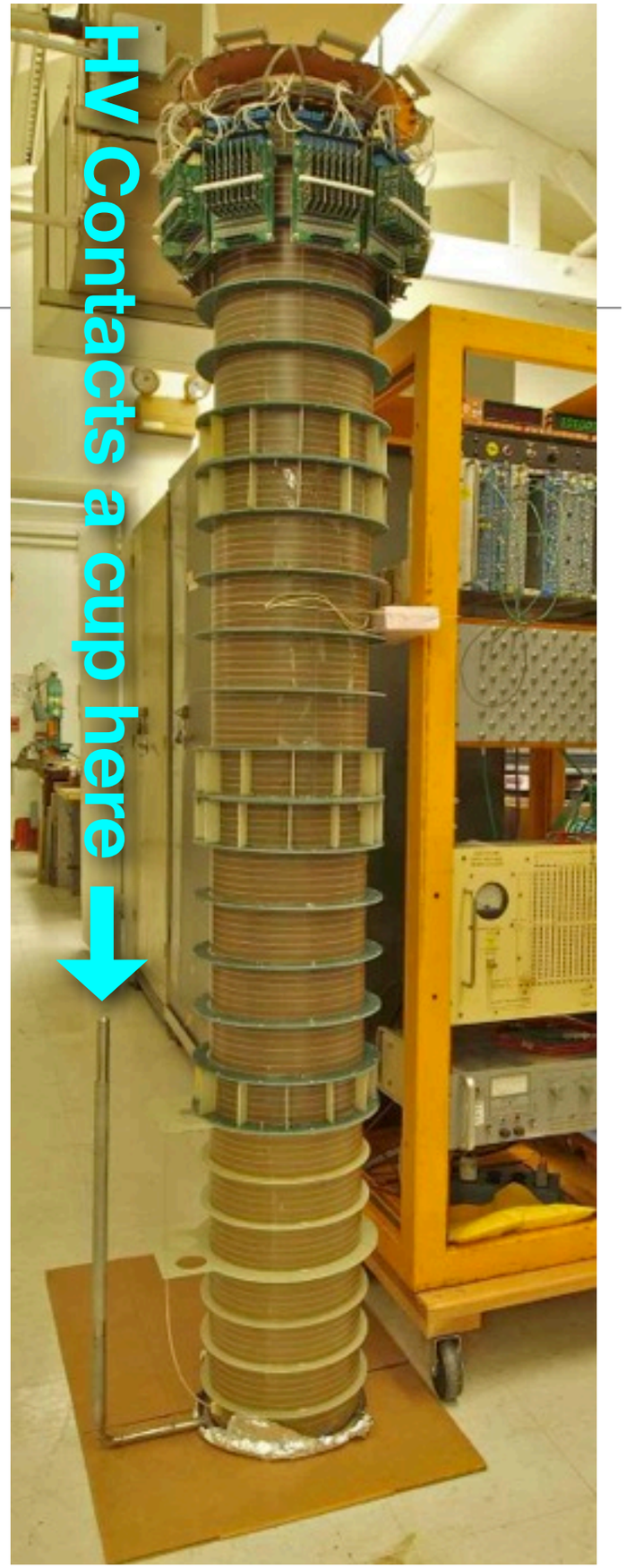
    - The longer the argon was exposed to air, the more oxygen would diffuse in it





Our Experience: Long Bo HV

- We also supplied the HV for Long Bo
- Long Bo was a 2 m long drift TPC put in LAPD last year
  - 2 m drift with 500 V/cm --> 100 kV
  - FT was tested to 120 kV for a few hours (open dewar & power supply could not be left)



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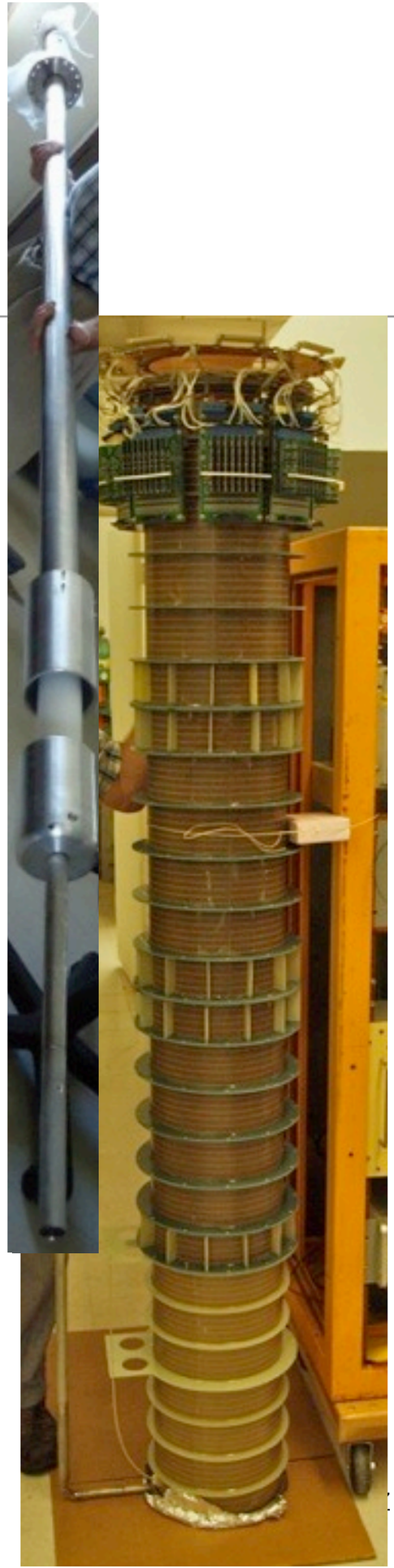

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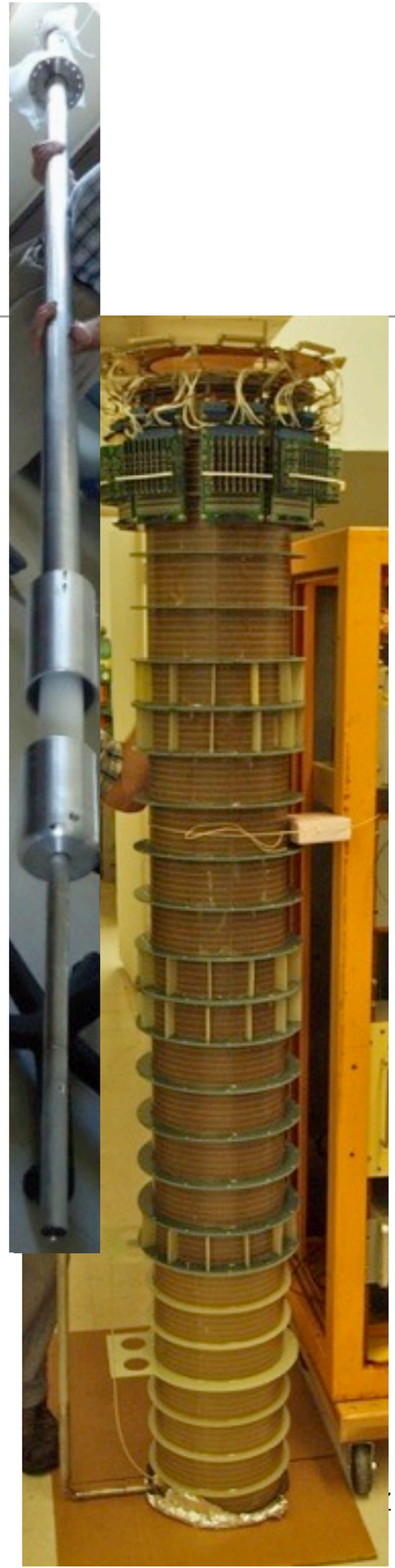

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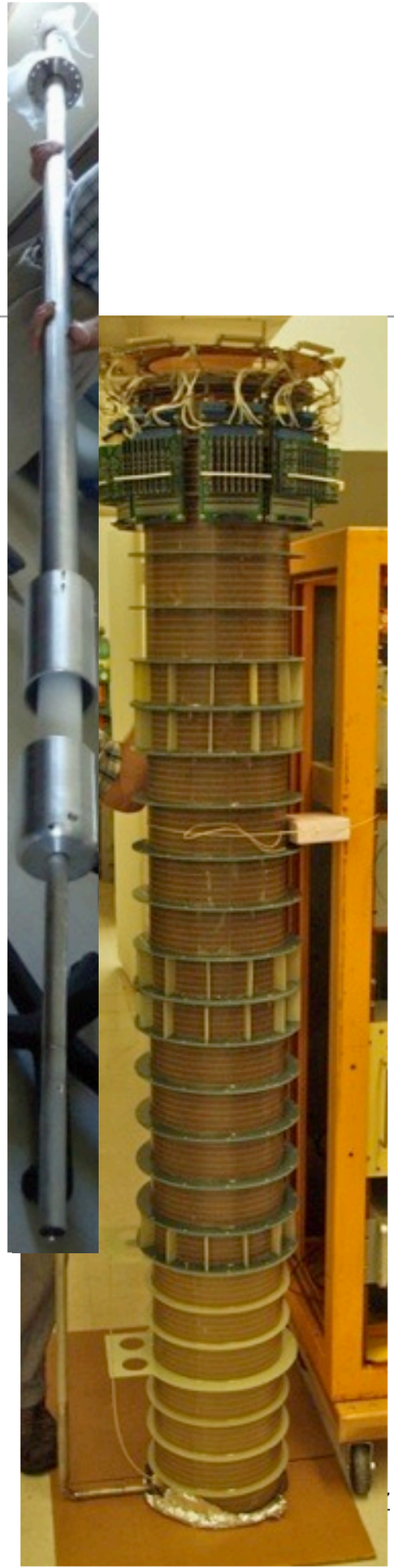

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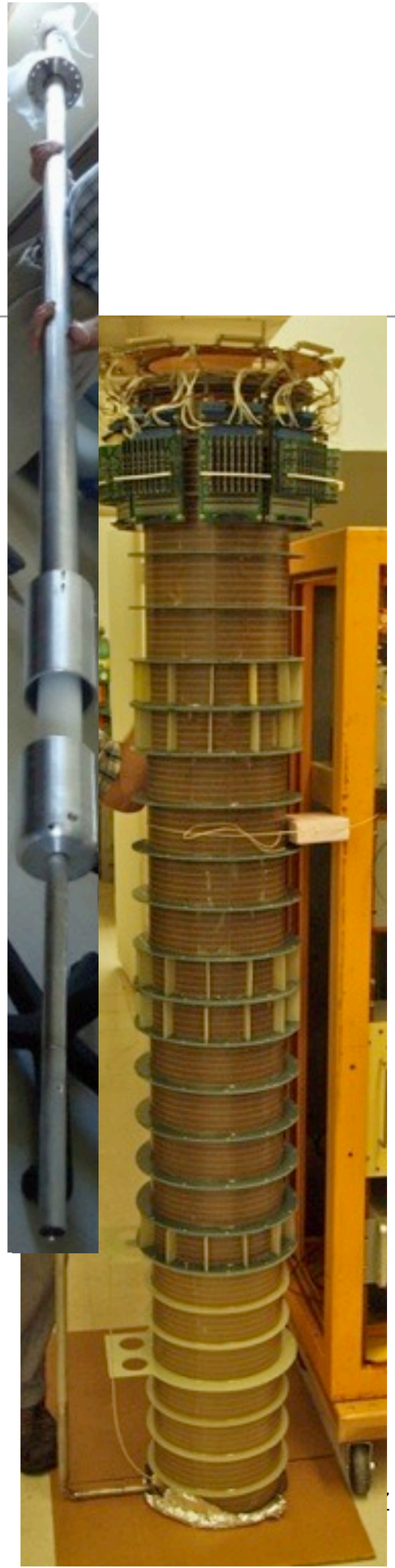

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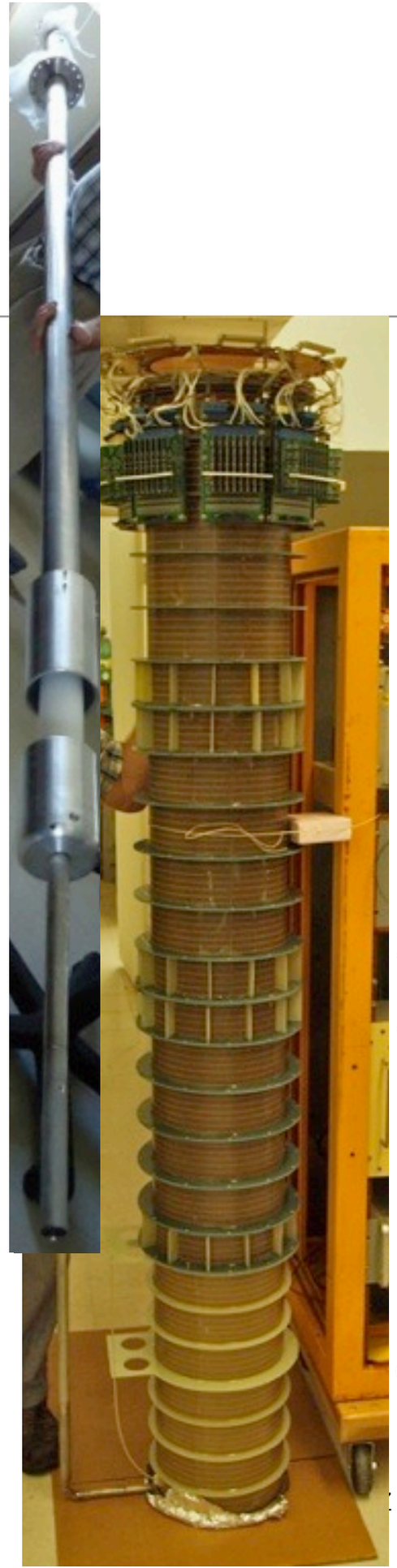

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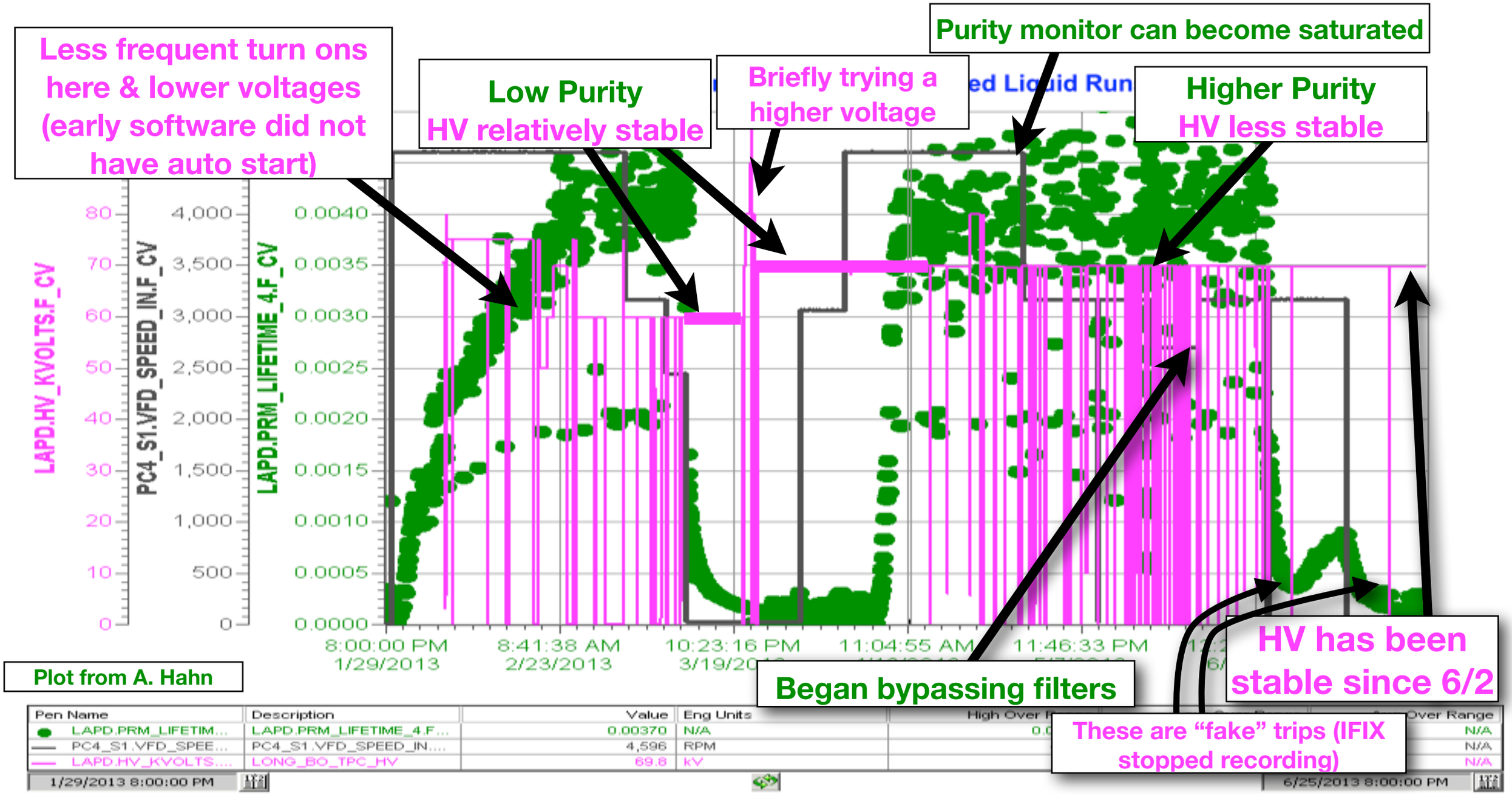
- We eventually determined **the HV stability is related to the purity of the LAr**



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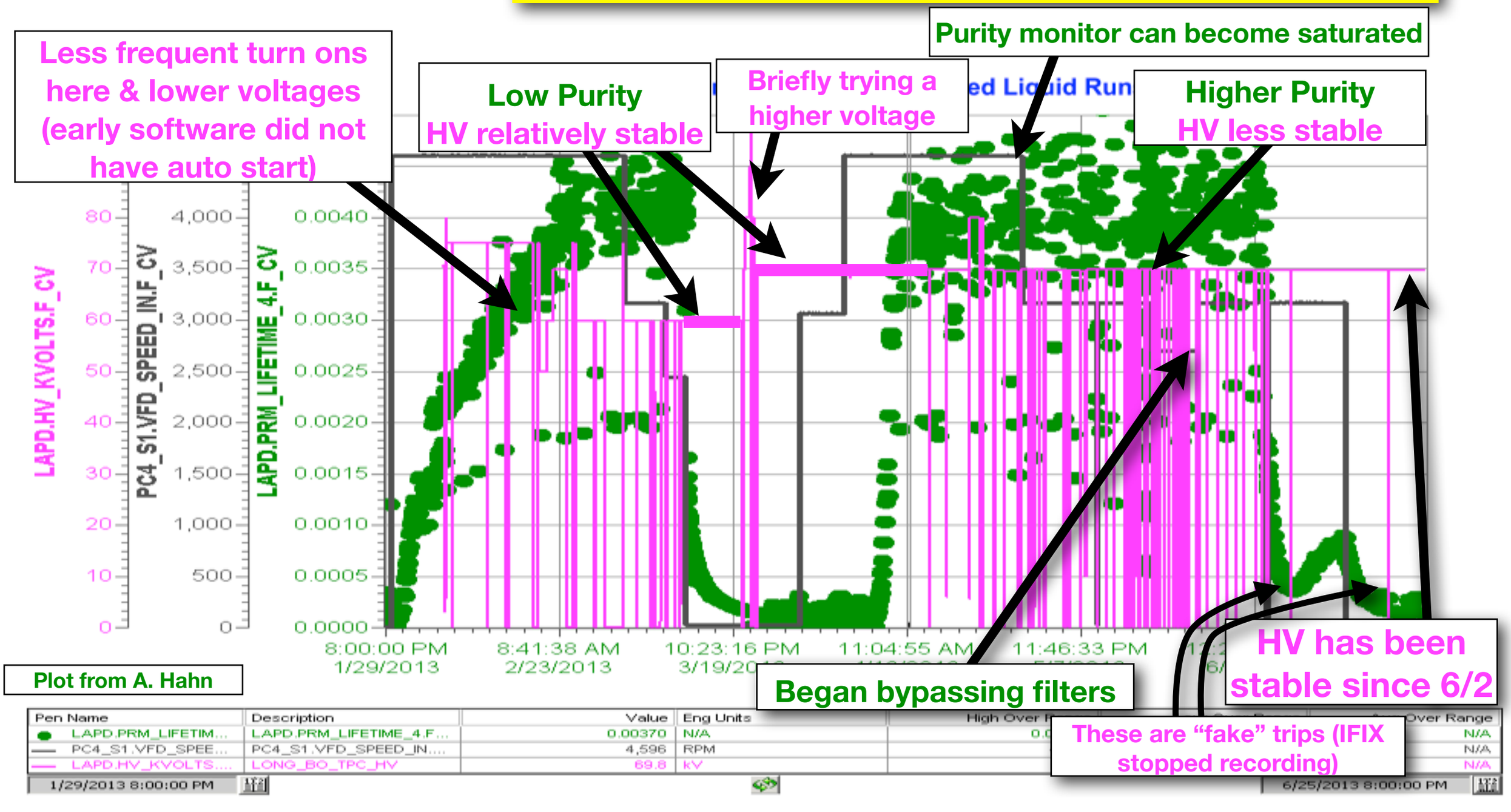

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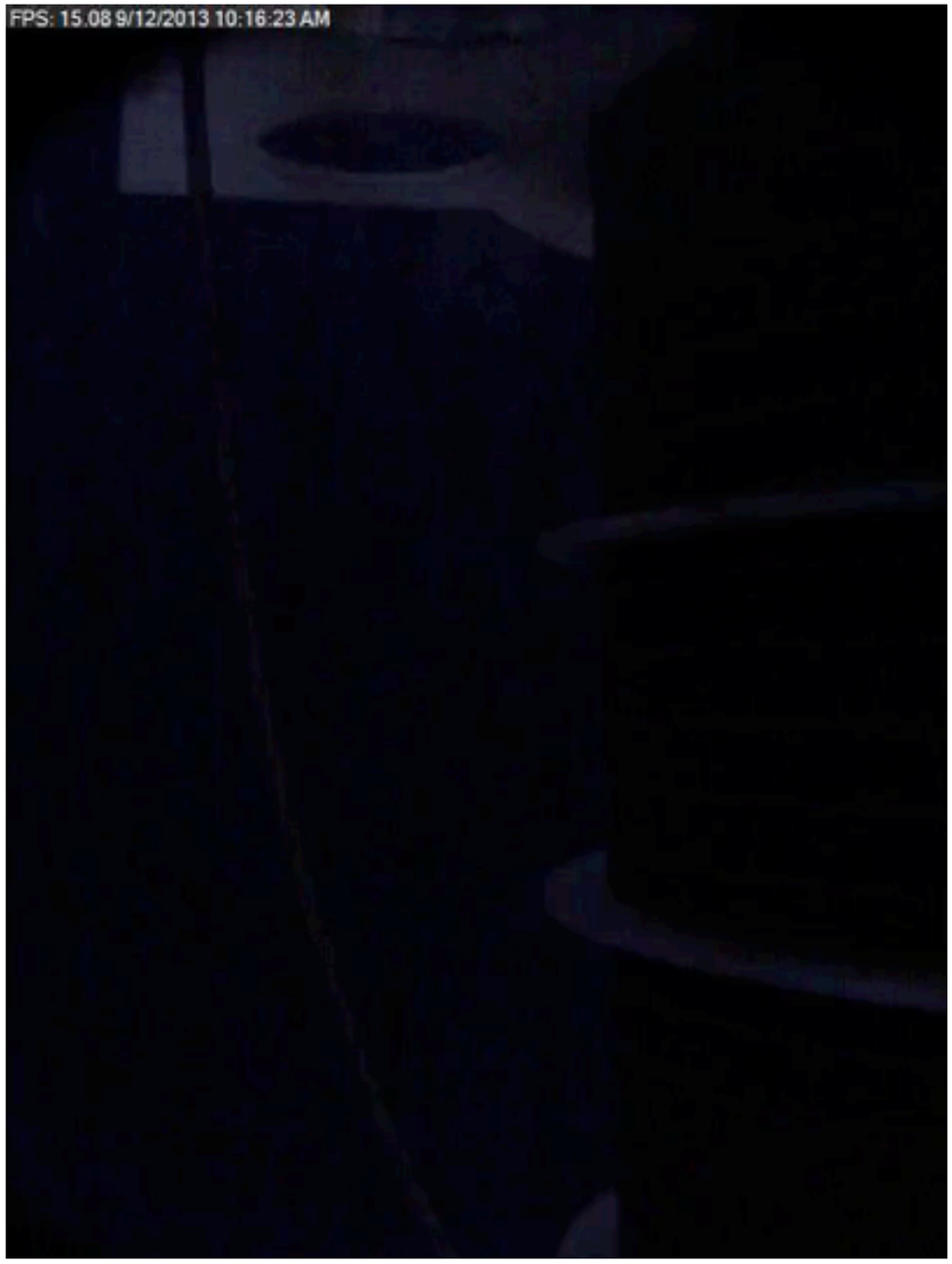

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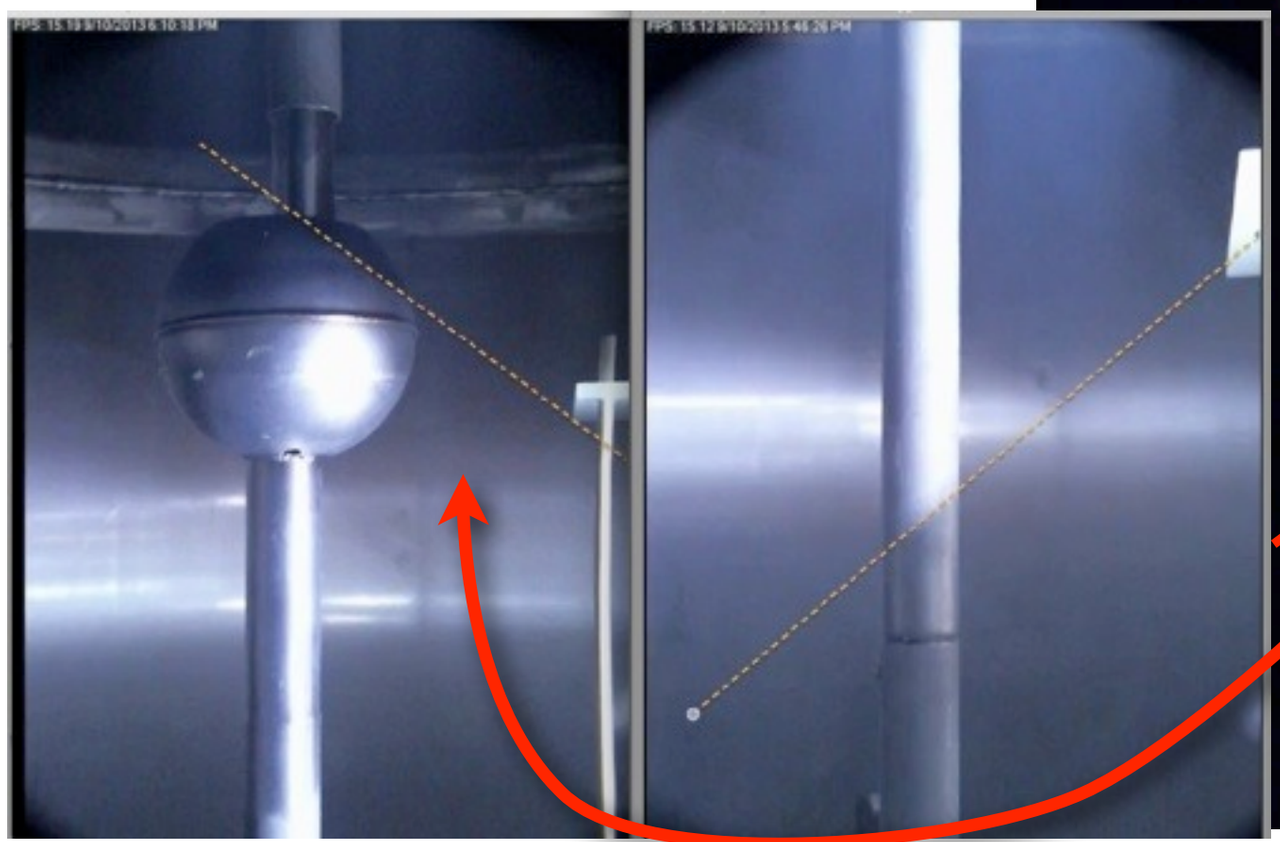

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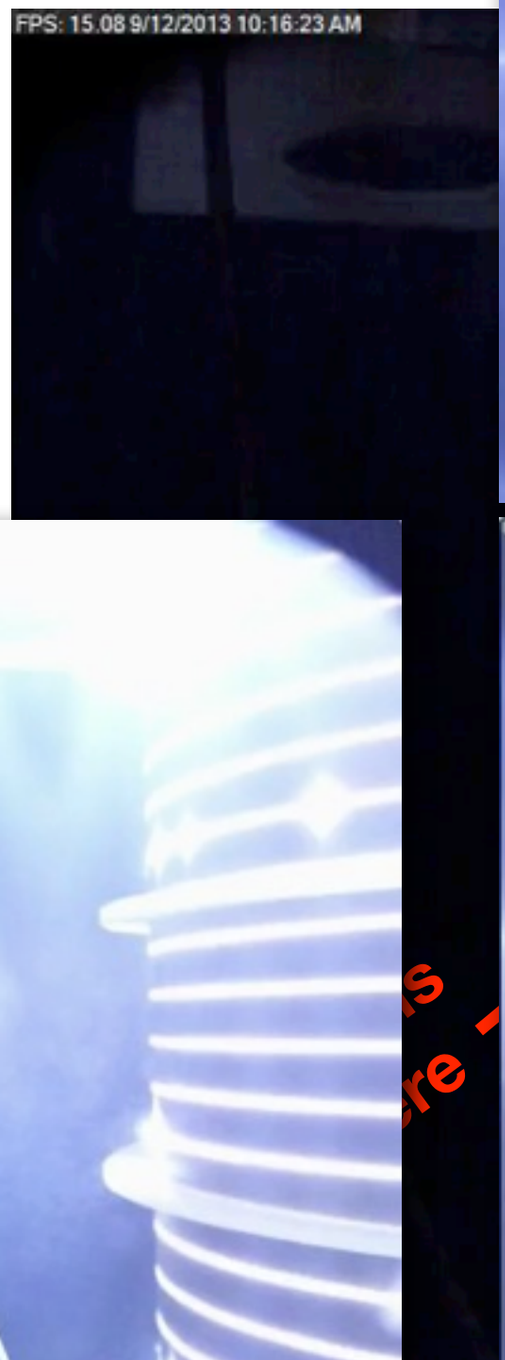
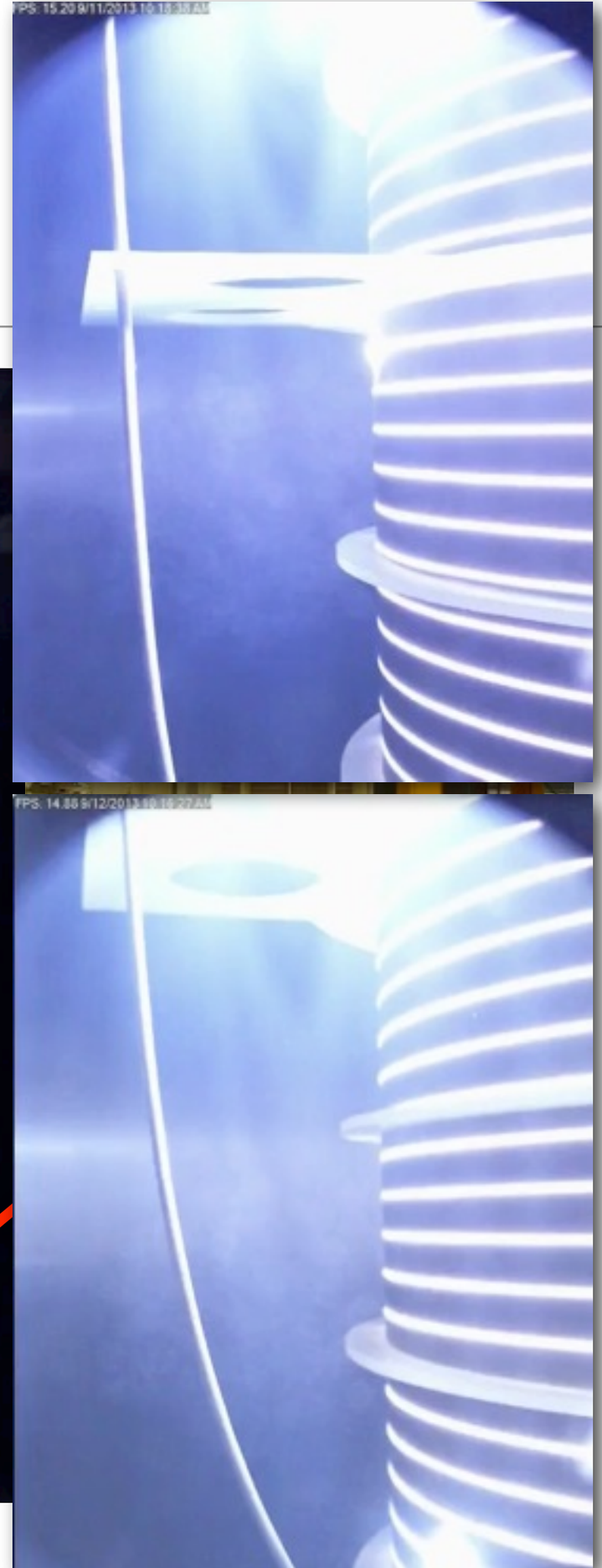
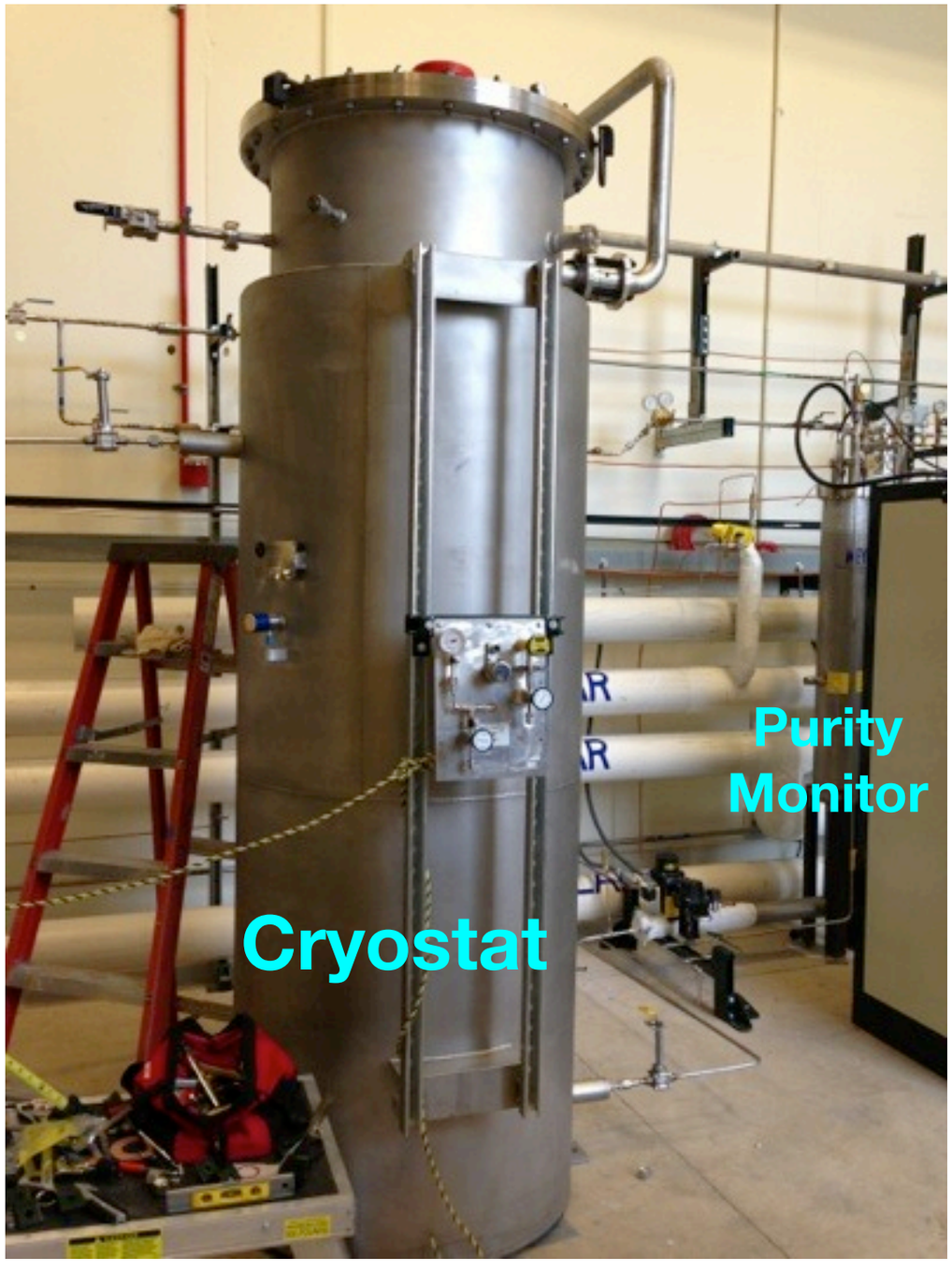




My Experience: HVC at LArTF

- Right now, we (MicroBooNE) are redoing the LAr electric strength test vs. distance in a more controlled environment at LArTF
    - Part of the phase I cryo work
- HVC!
    - Test setup idea:



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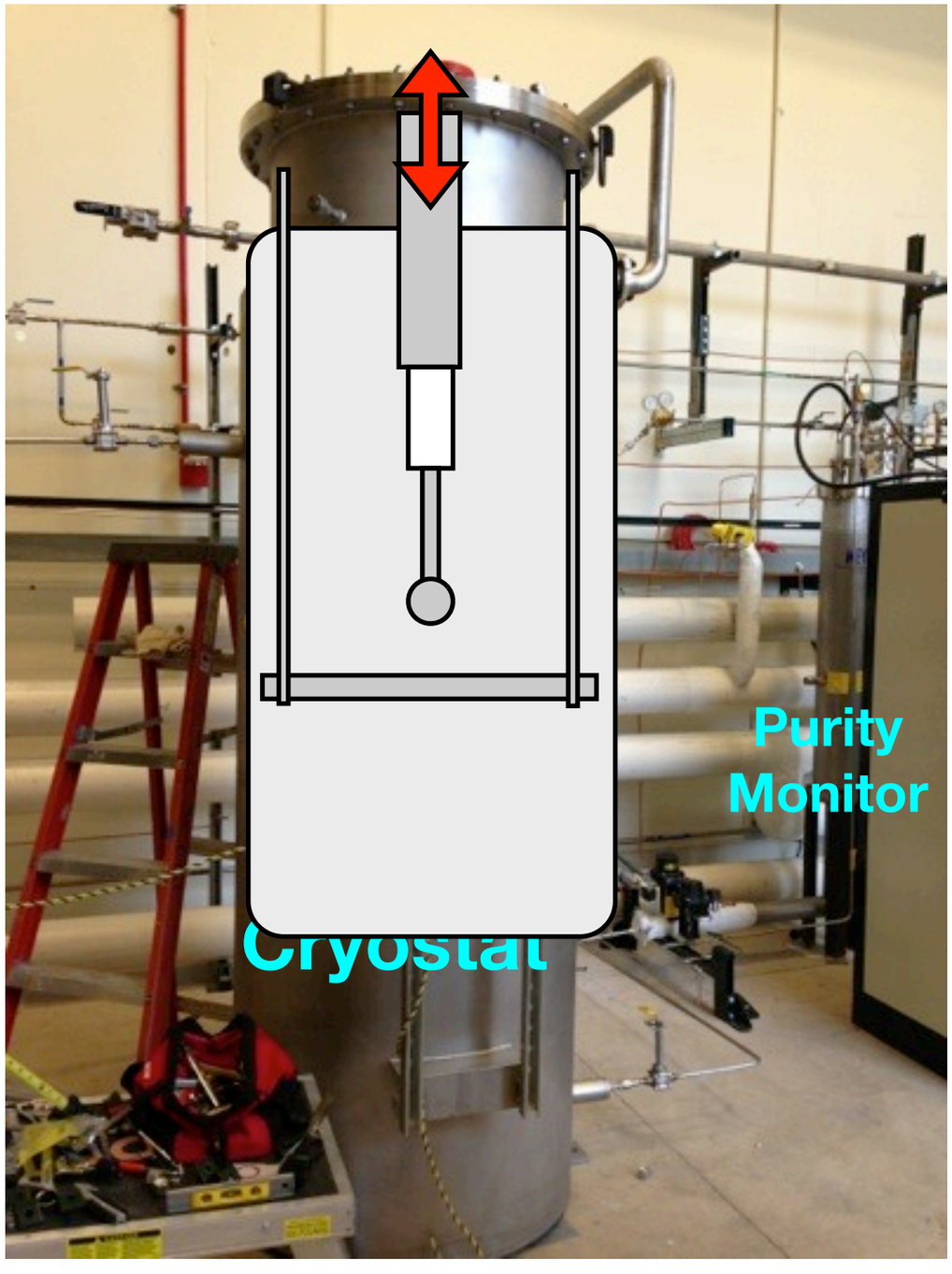
- Right now, we (MicroBooNE) are redoing the LAr electric strength test vs. distance in a more controlled environment at LArTF
    - Part of the phase I cryo work
- HVC!
    - Test setup idea:



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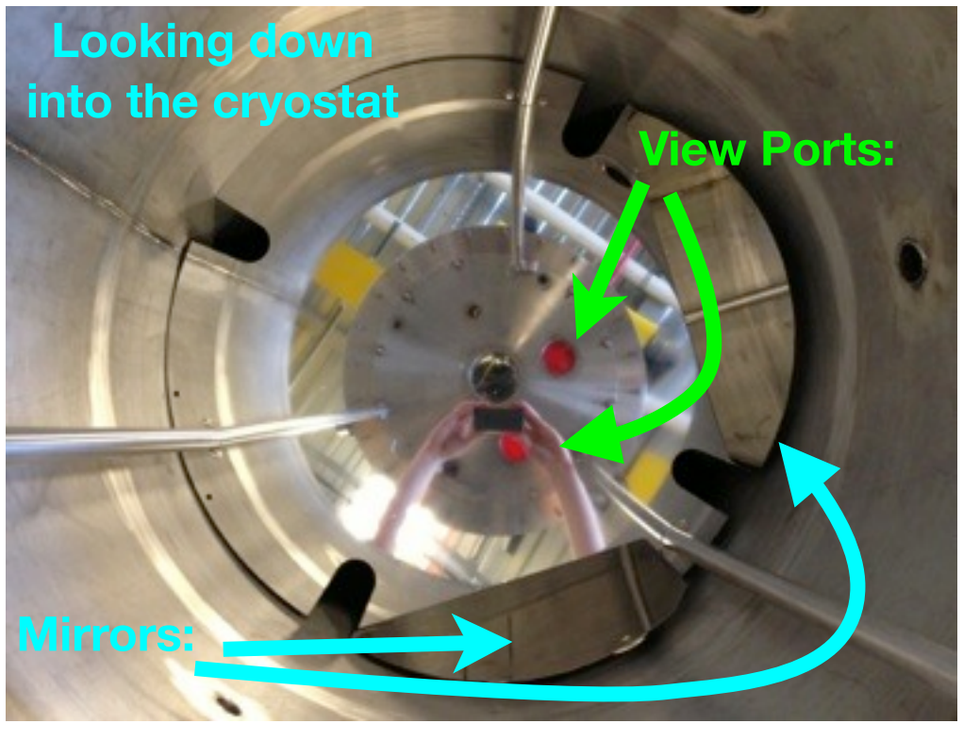

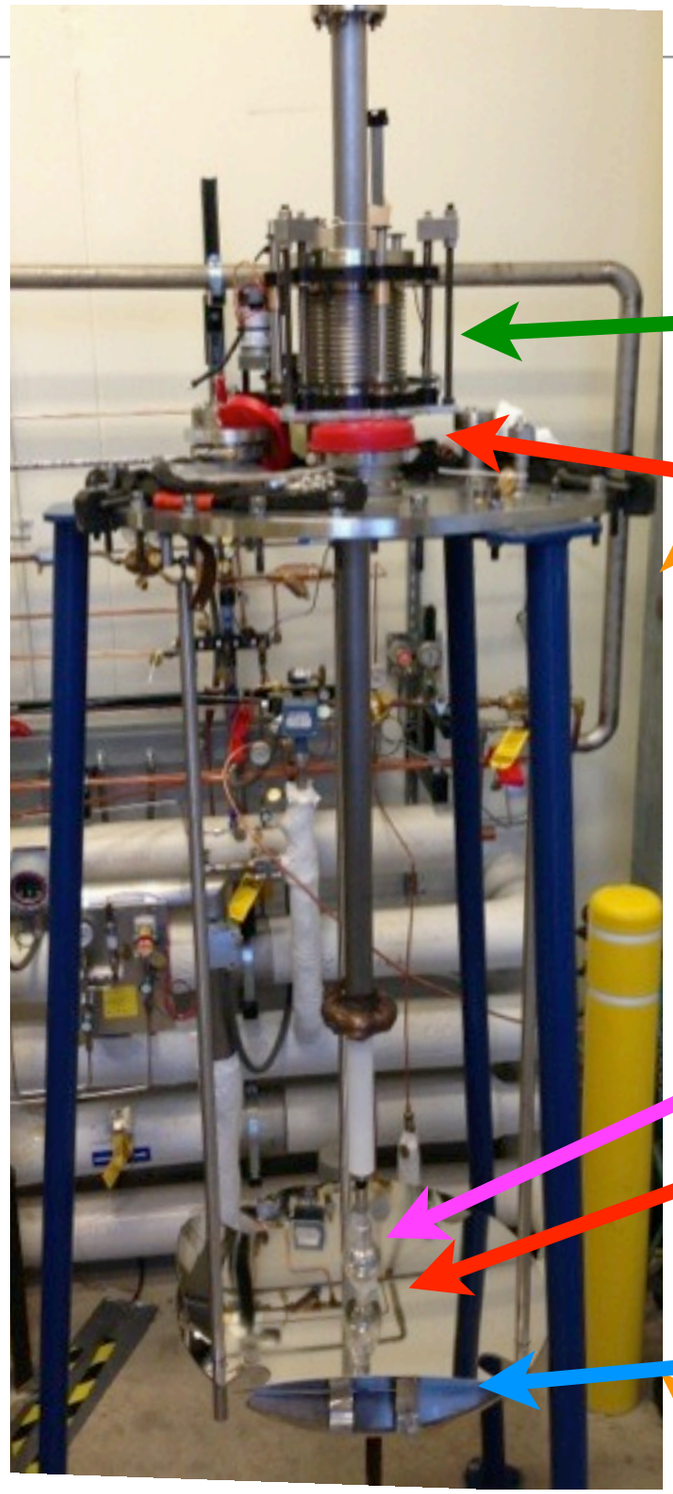

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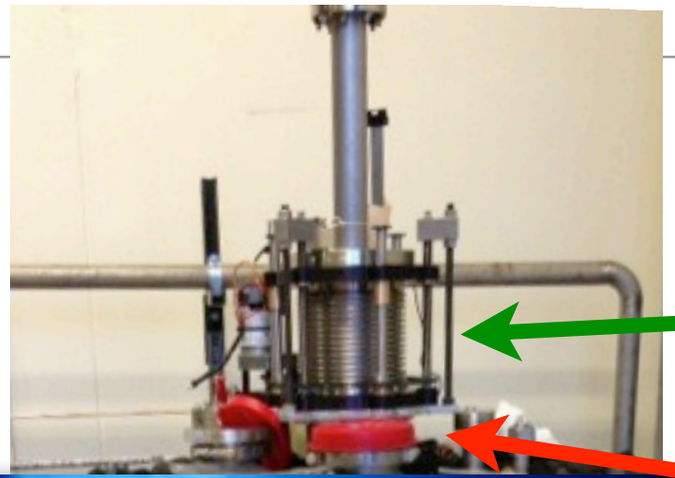

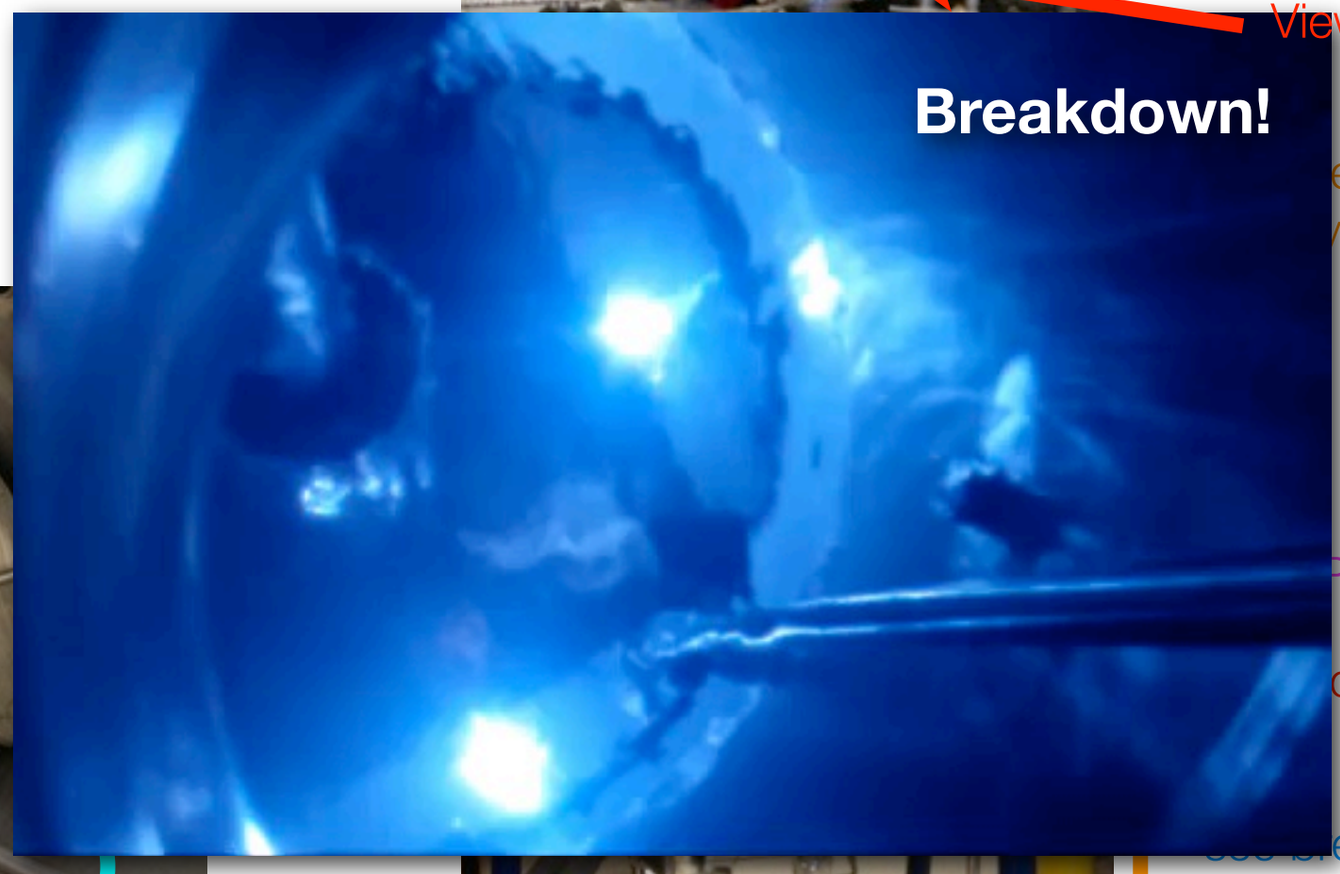

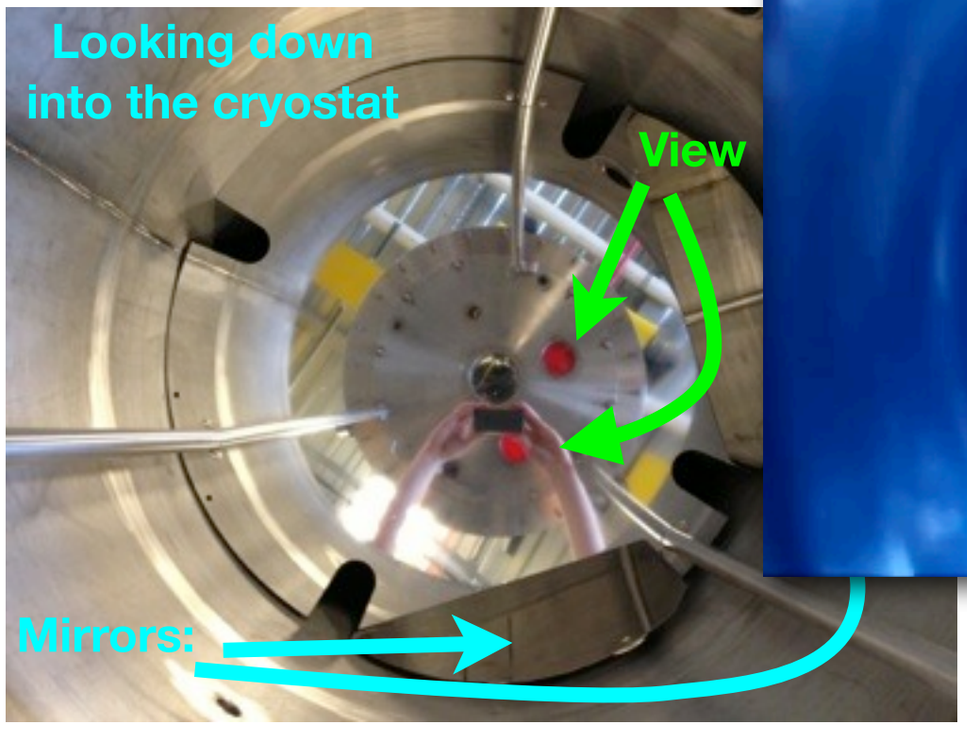

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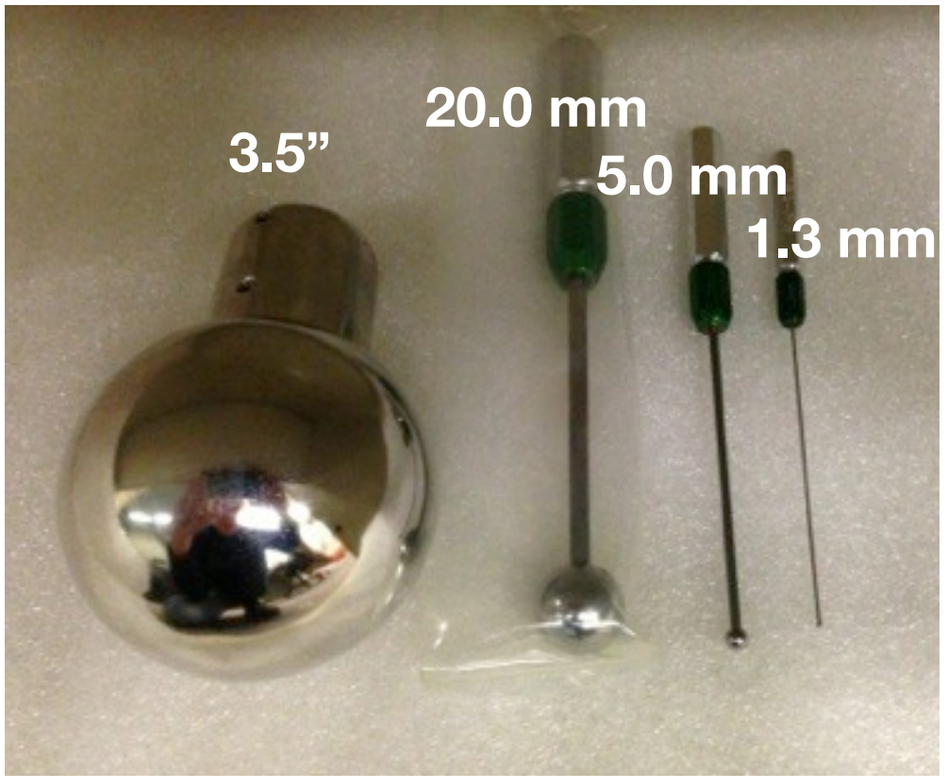

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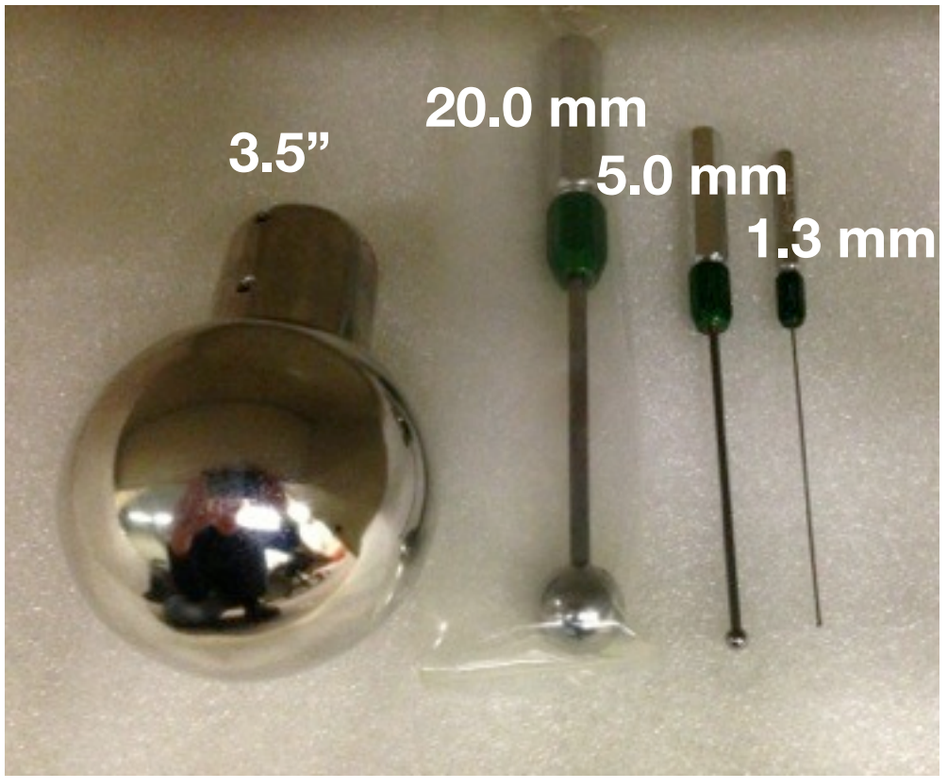

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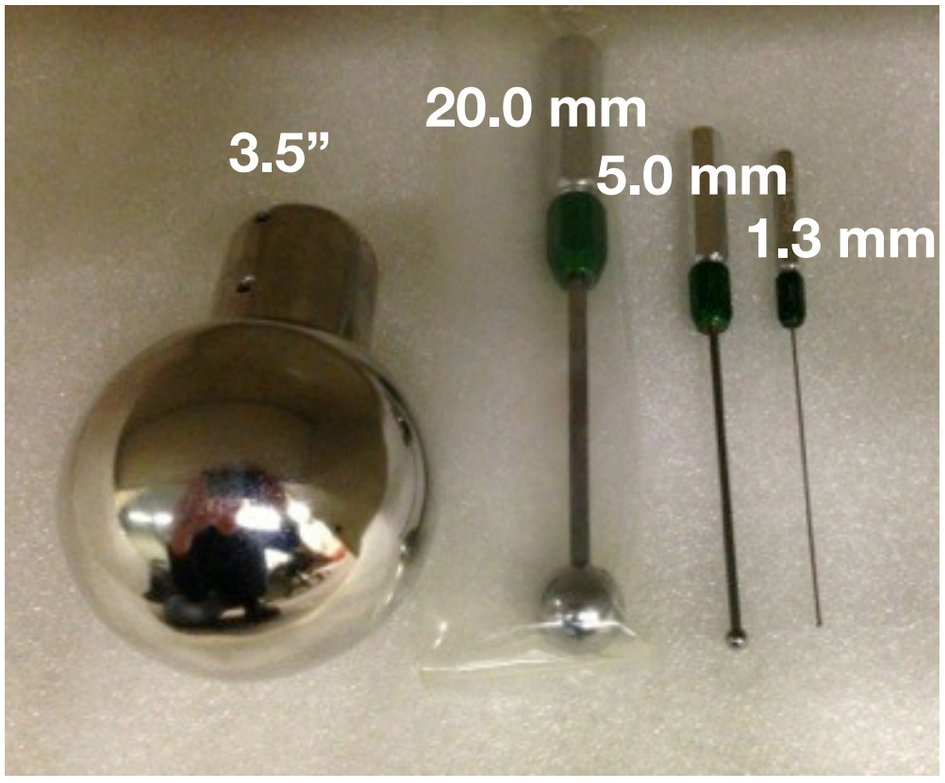

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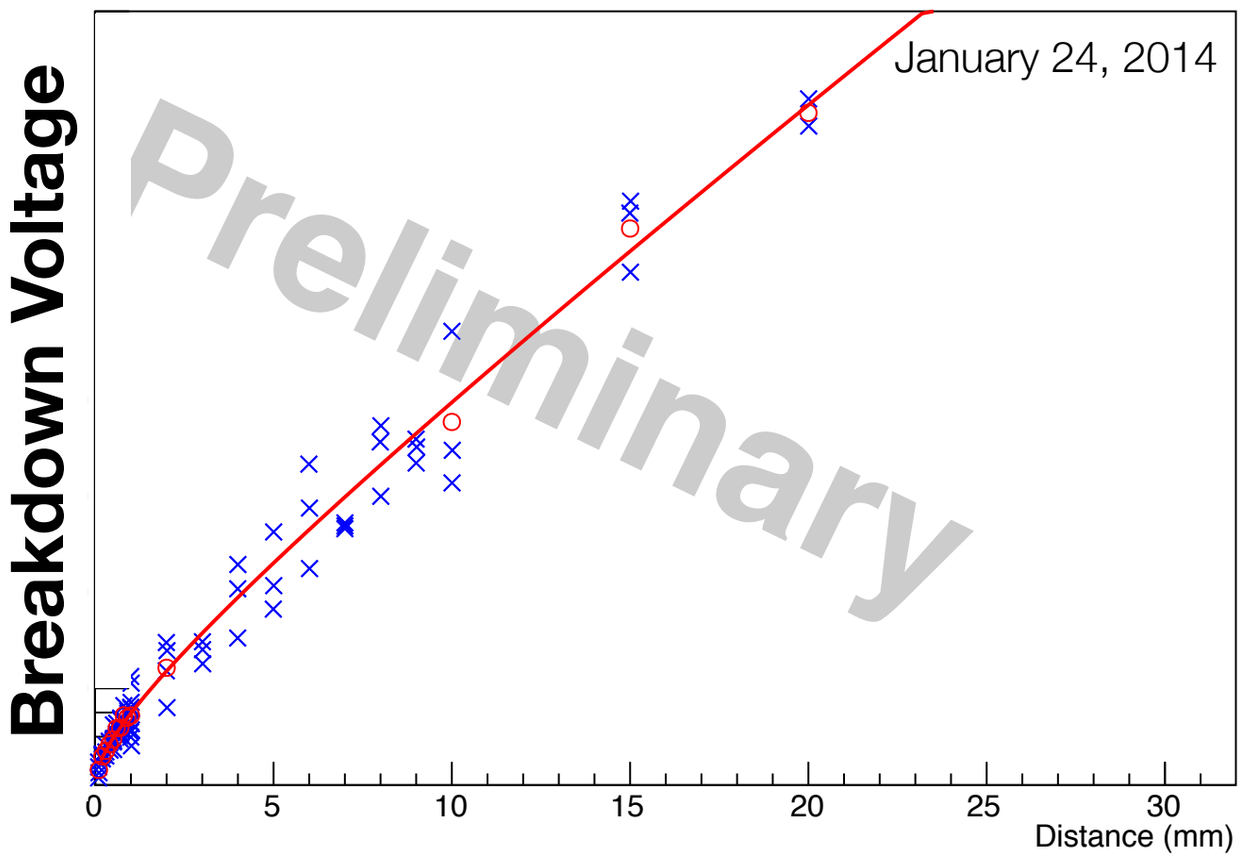

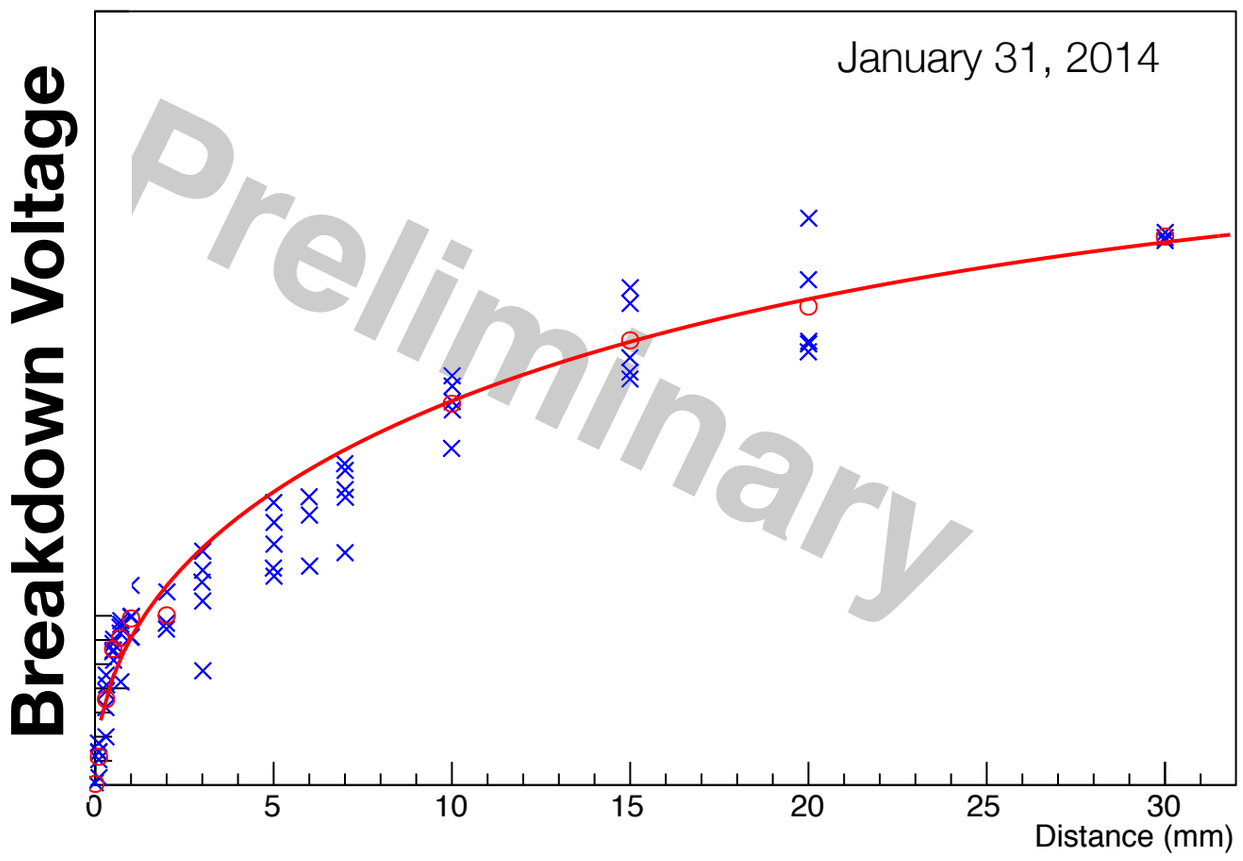

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    - We can vary distance (Resnati was fixed at 1cm)
    - We can study the effects of high field volume (probe size)

Additionally, We Would like to...

Others do not seem to be studying this

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- Study the **effect of surface material and conditions** on electric discharge
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- Test **polarity effects**
  - It's natural to ask how the results change if a +V is applied (instead of -V)
  - (Positive supply is available onsite -- some logistic contortions are needed to free it)

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- The effect of radioactivity on HV
  - Heavy particles such as neutrons or alpha particles are sometimes mentioned as the culprit for delayed breakdowns

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  - vs. purity
  - vs. configuration -- high field volume
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- These measurements have notable strengths over others' endeavors
  - FT performance
  - Range of movement
  - Range of purities
  - Probe shape

In Closing (2/3)

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- What we will need:
  - To establish the system at the PAB: Bringing the cryostat from LArTF
    - Approximately $50,000 M&S: cryogenic hardware, machining, welding
      - Feedthroughs, condenser, internal filter, hook up to existing argon source, consultant, purity monitoring system, DAQ, hook up to gas analyzers, controls, camera
  - 3 months tech ($40k); 1 month engineer ($25k)

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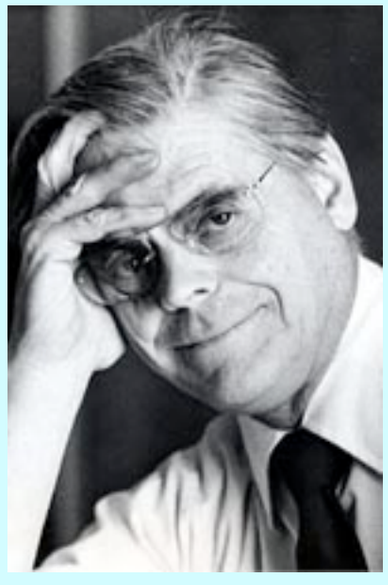

Back Up Slides

Study Bubbles and Temperature

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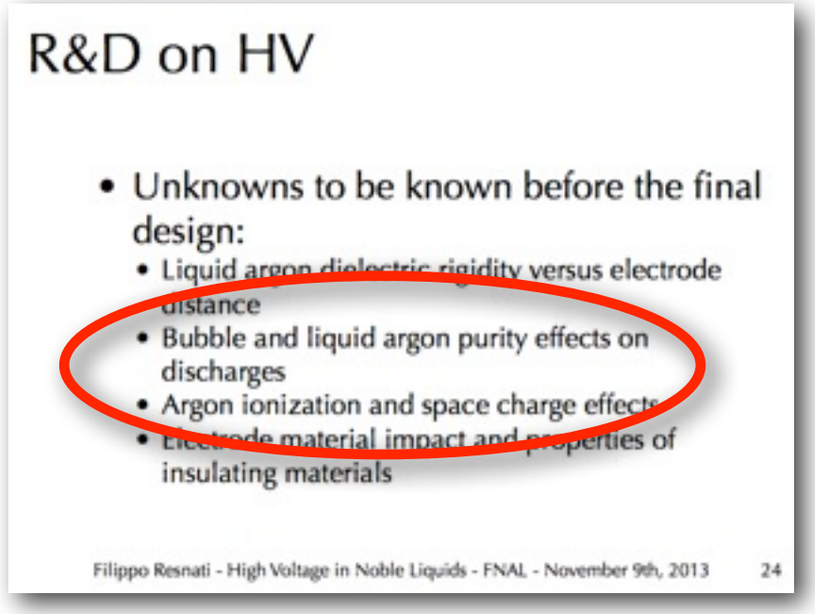
  - Is the narrative actually true? Bubbles do not always initiate a breakdown



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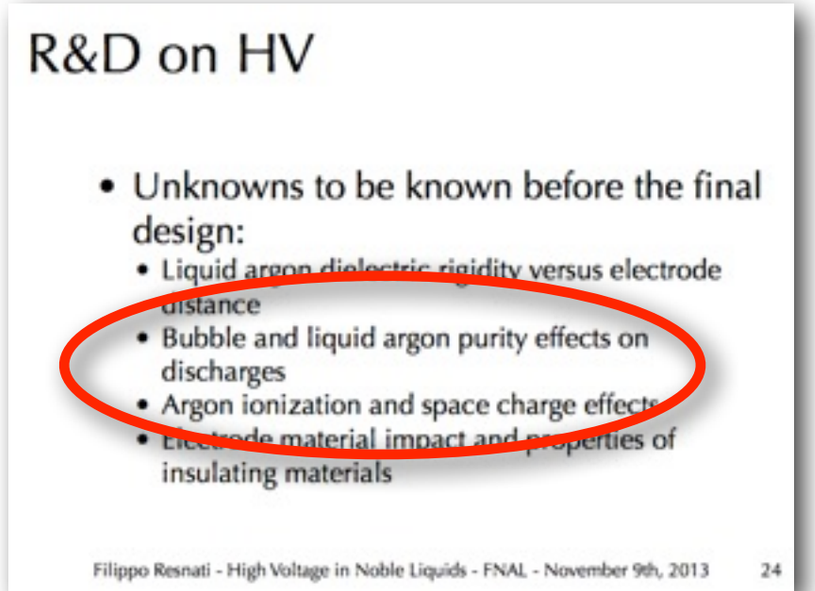
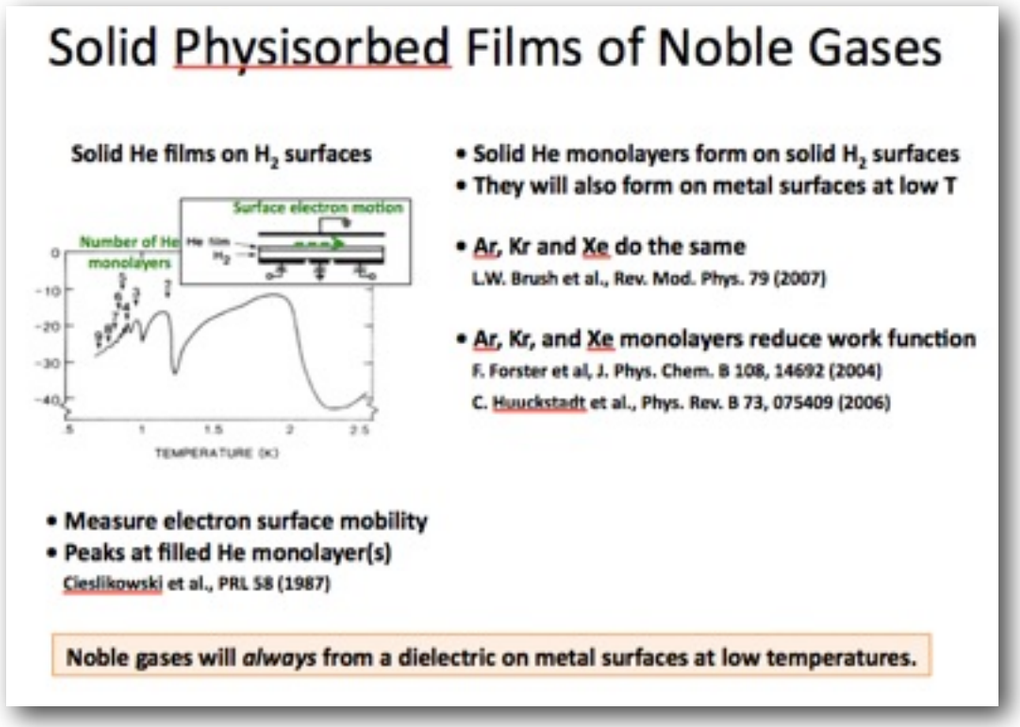
  - Is the narrative actually true? Bubbles do not always initiate a breakdown
- Study the temperature dependence
  - Source of bubble = bad ?
  - There is an idea that argon plates out on cold surfaces trapping impurities that lead to HV sparks:





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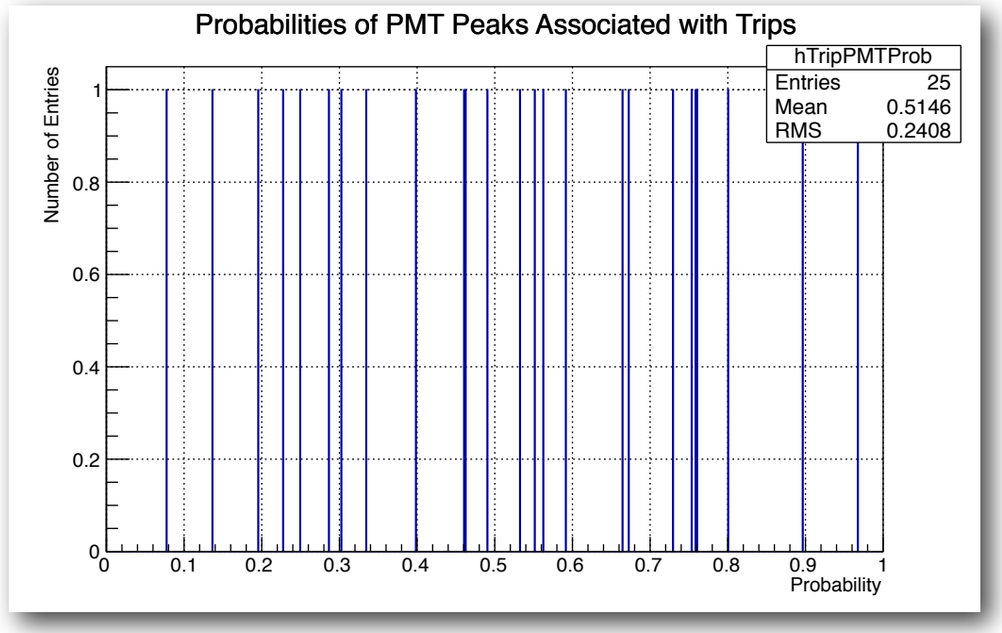
  - An idea was that cosmic showers were triggering the breakdowns
    - We did an initial test of this at LAPD
      - The counter had limited coverage (~35x35 scintillator ~12’ above the TPC)
      - No correlation (lartpc docdb #1001)
    - We could redo this test and easily improve the coverage



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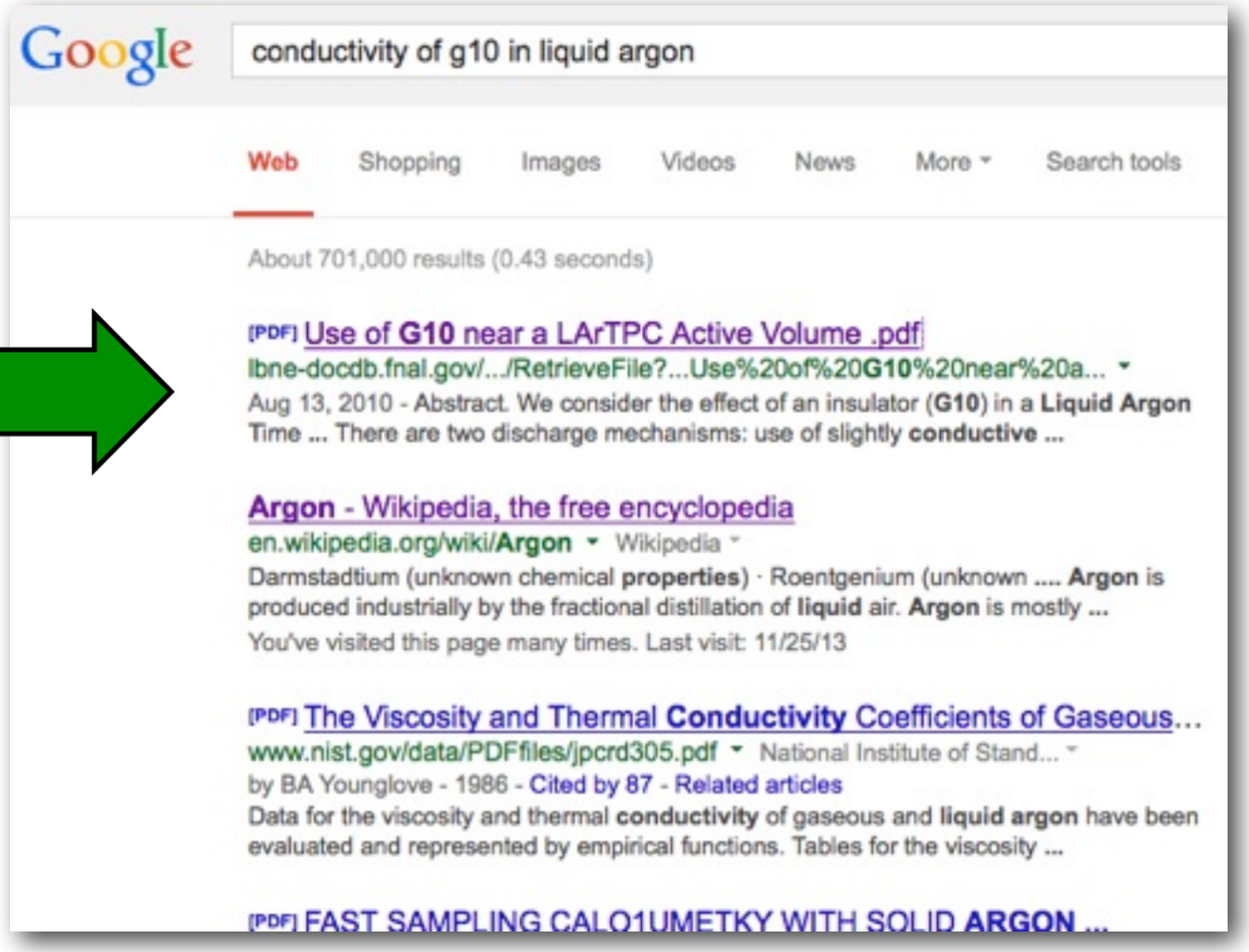

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